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Conceptual Design Of A Basic Production Facility For The XM587E2/XM724 Electronic Time Fuzes

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HDL-CR-77-048-1 — Conceptual Design of a Basic Production Facility for the XM587E2/XM724 Electronic Time Fuzes, by Edward M. Stryker

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This report documents the efforts and accomplishments of the basic production facility program for the XM587E2/XM724 electronic time fuzes. Phase I consisted of an engineering investigation of the conceptual design of two automated assembly lines. One of the automated assembly lines assembles, tests, and inspects either the XM587E2 electronic time fuze or the XM724 electronic time fuze and the other automated assembly line assembles, tests, and inspects the safing and arming (S&A) modules for these fuzes. Phase II consisted of writing specifications for the machines/ stations for the automated

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assembly lines, conducting unit product cost (UPC) estimates, and analyzing the automated assembly line amortization time period. Phase II also included reliability - availability - maintainability (RAM) and hazard analyses.

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1. INTRODUCTION

This report documents the efforts and accomplishments of the basic production facility (BPF) program for the XM587E2/XM724 electronic time fuzes. Plase I consisted of an engineering investigation of the conceptual design of two automated assembly lines. One of the automated assembly lines assembles, tests, and inspects either the XM587E2 electronic time fuze or the XM724 electronic time fuze and the other automated assembly line assembles, tests, and inspects the safing and arming (S&A) modules for these fuzes. Phase II consisted of writing specifications for the machines/stations proposed for the automated assembly lines, conducting unit product cost (UPC) estimates, and analyzing the automated assembly line amortization time period. Phase II also included reliability-availability-maintainability (RAM) and hazard analyses.

The XM587E2 and XM724 fuzes are digital electronic time fuzes for use in ammunition for the 4.2-inch mortar, 105mm howitzer, 155mm howitzer, 175mm gun, and the 8-inch howitzer. The overall length of the fuzes is 5.27 inches nominal, and the weight is 1.70±0.4 pounds. The external configuration of the XM587E2/XM724 fuzes is shown in figure 1.

The S&A modules for both fuzes are functionally and physically identical. Thus, the assembly of the S&A modules can be accomplished on ore automated assembly line.

The functional characteristics of the two fuzes differ slightly in that the XM587E2 fuze provides electronic time function with point detonation backup and point detonation only, whereas the XM724 fuze provides electronic time function with a limited point detonation capability. Due to the differences in functional characteristics, there is a slight difference in the internal physical figurations of the fuzes.

In the XM587E2 fuze, the point detonation backup firing pin is on the bias spring, whereas, in the XM724 fuze, the firing pin has been removed from the bias spring. There is also an extra track on one of the printed wiring boards in the XM724 fuze.

The minor physical configuration differences of the fuzes does not present any problem from the assembly standpoint in that only a probe is required to verify the presence or absence of the firing pin on the bias spring, depending upon which fuze is being assembled.

The automated assembly line concepts documented in this report are intended to have an output capability of 100,000 units per month on a 1-8-5 production basis (one shift - 8 hours per day - 5 days per week) and a capability of 290,000 units a month on a 3-8-7 production

XM587E2/XM724 FUZE

Figure 1. XM587E2 fuze external configuration

basis (three shifts - 8 hours per day - 7 days per week).

The automated assembly lines utilize standard, proven, commercially-available machines to the greatest extent possible. The custom-designed machines incorporate the use of existing, commercially-available components with proven performance to the greatest extent possible.

Design changes which are proposed to facilitate the assembly of the S&A module or fuzes by the automated assembly machines are not included in this report. They have been submitted as 19 engineering change proposals (ECPs). The automated assembly line concepts contained in this report assume approval of these ECPs.

The level of automation described in this report is considered to be optimum at the present time. It does not presently appear necessary to include the mechanization for automated assembly/fabrication of any major components beyond those described in this report.

2. SUMMARY

2.1 Automated Assembly Line Development

The development of automated assembly lines for the production of a specific product is accomplished by proceeding through a series of rather specific steps or phases. These phases define the program from design concept through production of the given product. The phases which apply to the program documented in this report are as follows:

- Conceptual design.
- Automated assembly machine design, development, fabrication, and debug.
- Machine acceptance run.
- Factory shakedown.
- Production.

A brief discussion of each of these phases is presented below in order to indicate the relationship of each phase of the program described in this report with a total development program for automated assembly line equipment. Since a product to be assembled on automated assembly line equipment requires special tolerancing and design techniques, the product design is an evolutionary procedure throughout the automated assembly machine development phases.

2.1.1 Conceptual Design -- This phase generally consists of analyzing specific assembly and inspection operations to determine if they can be effectively performed by individual automated assembly machines.

This analysis forms the basis upon which all other factors affecting the design of the automated assembly line are generated. Following the basic concept design phase, the following information is usually generated:

- Assembly flow chart.
- Physical plant layout.
- Amortization data.
- Automated assembly machine specifications.

- Management and data acquisition system specifications.

In this particular program, the conceptual design phase was further subdivided into two phases. This report covers the Phase I conceptual design activities.

2.1.2 Automated Assembly Machine. Design, Development, Build, and Debug -- This phase consists of the design, development, fabrication, and debug of individual automated assembly machines. During this phase, a quantity of parts and subassemblies is used and consumed in development, tryout, and adjustment of the machine and tooling components.

2.1.3 Machine Acceptance Run -- This is a qualifying test run in which a predetermined number of units of properly assembled product are produced within a predetermined amount of time. Qualification of the machine acceptance run would normally result in release of the equipment for production or to the buyer. Acceptance hardware in quantity to satisfy the final machine acceptance run is required. Assemblies from a machine acceptance run usually result in deliverable hardware.

2.1.4 Factory Shakedown -- This phase of the program covers the time frame in which the automated assembly machines are set up in a production facility and run in a production environment. Problems caused by the production environment are solved during the factory shakedown. Examples of these problems include variations between lots of parts and mechanical deficiencies in the machine performance that are intermittent and difficult to isolate.

2.1.5 Production -- This phase involves continuous production of the specific product at rates specified by a contract or product demand. A diagram of the phases described above, showing the approximate operating efficiency of the automated assembly machines over a time period, is shown in figure 2.

2.2 Automated Assembly Line Philosophy and Approach

Honeywell's philosophy of multi-machine automated assembly lines utilizes the concept of modularized multi-station automated assembly machines. This philosophy is based on the experience that Honeywell has gained as a designer, builder, and user of automated assembly and inspection machines for high-volume automated assembly lines. The modularized automated assembly machines are united into a production system through the application of input-output part and subassembly transfer and storage capabilities between machines.

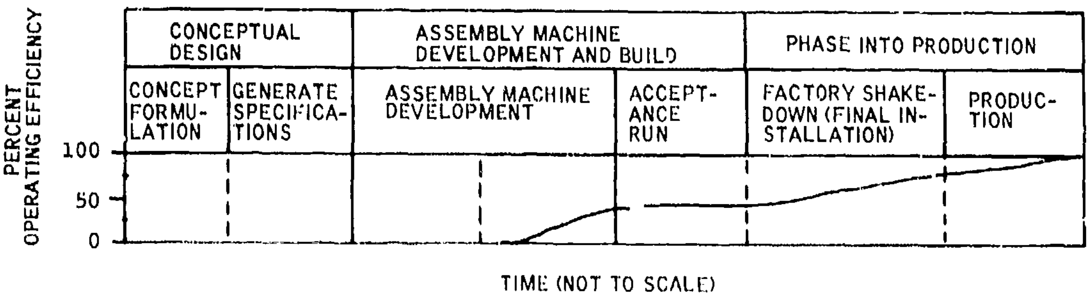


Figure 2. Phases in the development of an automated assembly line

The practice of incorporating independent modularized automated assembly machines into an automated assembly line has resulted in a more efficient production capability. During those time periods when an automated assembly machine is undergoing repair, the automated assembly line has the capability of continuing production of the given product.

The machines proposed for the XM587E2/XM724 fuze BPF program and discussed in this report are of the following types:

- Honeywell dial-index automated assembly machines.
- Commercial electronic component insertion equipment.
- A commercial flow solder machine.
- Commercial spring winders.
- Automated test equipment.
- An automated encapsulation system.
- Manual assembly operations.

All of the commercial equipment has been selected based on proven performance in factory situations. The dial-index automated assembly machines are fabricated as modularized production units and have been proven by Honeywell on many previous production programs.

The automated test equipment and automated encapsulation machine are of special designs, but are similar to machines designed and utilized on other Honeywell production programs.

Manual assembly is necessary for certain operations due to the complexity of the production process. The use of automated assembly in these operations is neither physically practical nor economically sound. Several manual assembly operations are proposed within the automated assembly lines. These operations are required because the physical shape of the parts/subassemblies and/or the time required for handling can best be accomplished by a manual operation. An example of a manual operation is the installation of the printed wiring board and the subsequent mating and soldering of five lead wires. Simultaneous mating of the five wires cannot be accomplished by machine operation since some adjusting is necessary. Soldering is then accomplished in an area inaccessible to machine type tooling.

This selection of machine and equipment will result in automated assembly lines capable of the required production rates.

2.3 S&A Module Automated Assembly Line Concept

The S&A module automated assembly line includes the use of dial-index automated assembly machines along with appropriate bowl, hopper, or magazine feed mechanisms and spring winders. The S&A module assembly line flow diagram is shown in figure 3.

Dial-index automated assembly machines utilize a mechanical drive that rotates and positions (indexes) a circular table by means of positive cam action mechanisms. The machine also simultaneously raises and lowers a reciprocating upper tool plate which accomplishes specific assembly, probing, or inspection tasks on the given part as it is moved around the circular table. Part assembly nests are placed around the outer edge of the circular table. The circular tables are available in various sizes depending on the assembly requirements. The part assembly nests are sized and configured to be compatible with the specific part and/or subassembly being fabricated. Parts feeding mechanisms and assembly, probing, and inspection stations are installed around or above the part assembly nests or on the upper tooling plate. Appendix A includes a more detailed discussion of typical Honeywell dial-index automated assembly machines.

The spring winders are standard items which have been adapted to fabricate the specific spring and to feed the finished springs into magazines.

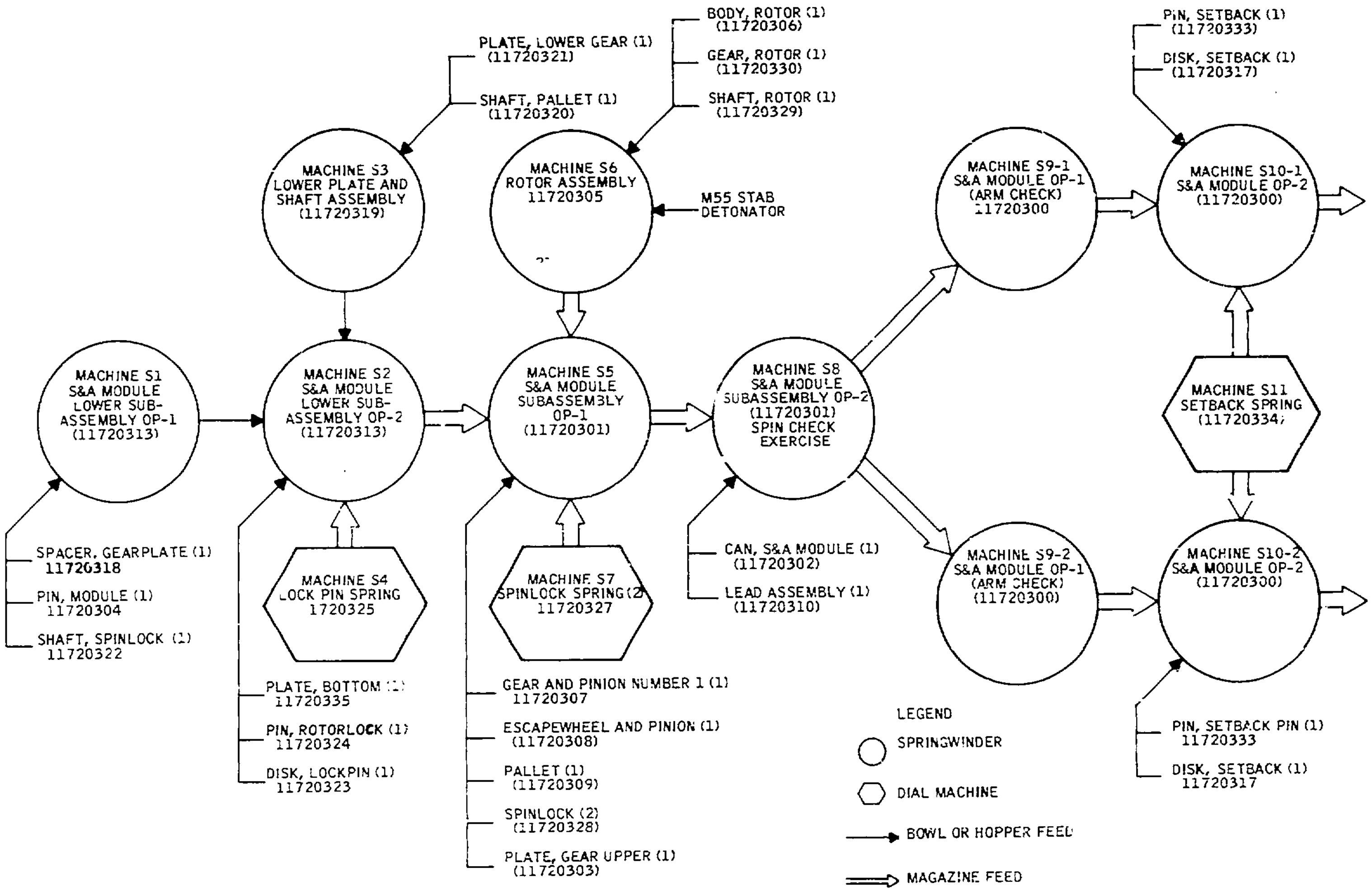


Figure 3. XM587E2/XM724 fuze S&A module automated assembly line process flow diagram

The automated assembly machines shown in figure 3 and identified as machines S1 through S7 accomplish the assembly of the S&A module. At the completion of the assembly step at Machine S5, the S&A module is complete except for installation of the outer can, output lead, and setback pin mechanism. In Machine S8, the S&A module is exercised in spin to check the gear train, after which the output lead and outer can are installed.

In Machine S9, the arm and nonarm spin levels are checked. In the final automated assembly machine, Machine S10, the setback pin mechanism is installed. The S&A modules to be lot sample tested are removed from the output of Machine S10.

The XM587E2/XM724 fuze S&A module automated assembly line concept is patterned after a similar automated assembly line developed for the M739 point detonating fuze S&A module. The machines for the M739 fuze S&A module automated assembly line were completed in July 1977.

A detailed discussion of the S&A module automated assembly line and a description of each machine function is presented in section 3.

2.4 Fuze Automated Assembly Line Concept

The assembly and inspection of the XM587E2/XM724 fuzes are complex operations and involve a significant number of tasks utilizing several types of assembly operations and types of equipment.

The types of operations required for the fuze automated assembly line are as follows:

- Axial-leaded component sequencing.
- Axial-leaded component insertion.
- Dual in-line package (DIP) integrated circuit insertion.
- Transistor insertion.
- Manual assembly operations.
- Wave soldering.
- Printed wiring board punch out.
- Automated assembly.

- Automated encapsulation
- Automated test.
- Crimping.

A flow diagram of the fuze automated assembly line is shown in figures 4 and 5.

A brief description of each of the above operations and the applicable machines is contained in the following paragraphs. A more detailed description of the fuze automated assembly line is contained in section 4.

The axial-leaded components, dual in-line package (DIP) integrated circuits, and transistors are all inserted into the printed wiring boards with standard X-Y component insertion equipment. Axial-leaded components and transistor are fed into the component inserter via tape which is contained on reels. The axial-leaded components are placed on the tape by means of a sequencing machine. The DIP integrated circuits are fed into the component inserter via slide magazines.

Several components are currently configured in such a way that they are not capable of insertion into printed wiring boards with standard component inserters. These specific components are as follows:

- Precision oscillator (11711427).
- Impact switch (11718418).
- Encapsulated transformer (11711448).
- Signal conditioner (10990455).

Since these components present very complex insertion problems, their insertion is currently defined as a manual operation. Design changes to the oscillator and signal conditioner currently in process may allow the use of machine insertion equipment.

In order to perform the automated component insertion operation efficiently, the printed wiring boards are configured with several boards on an array. The array is processed through the component inserter, manual assembly operations, and wave soldering operations. The individual printed wiring boards are then separated from the array by a punch out operation using a self-contained bench press.

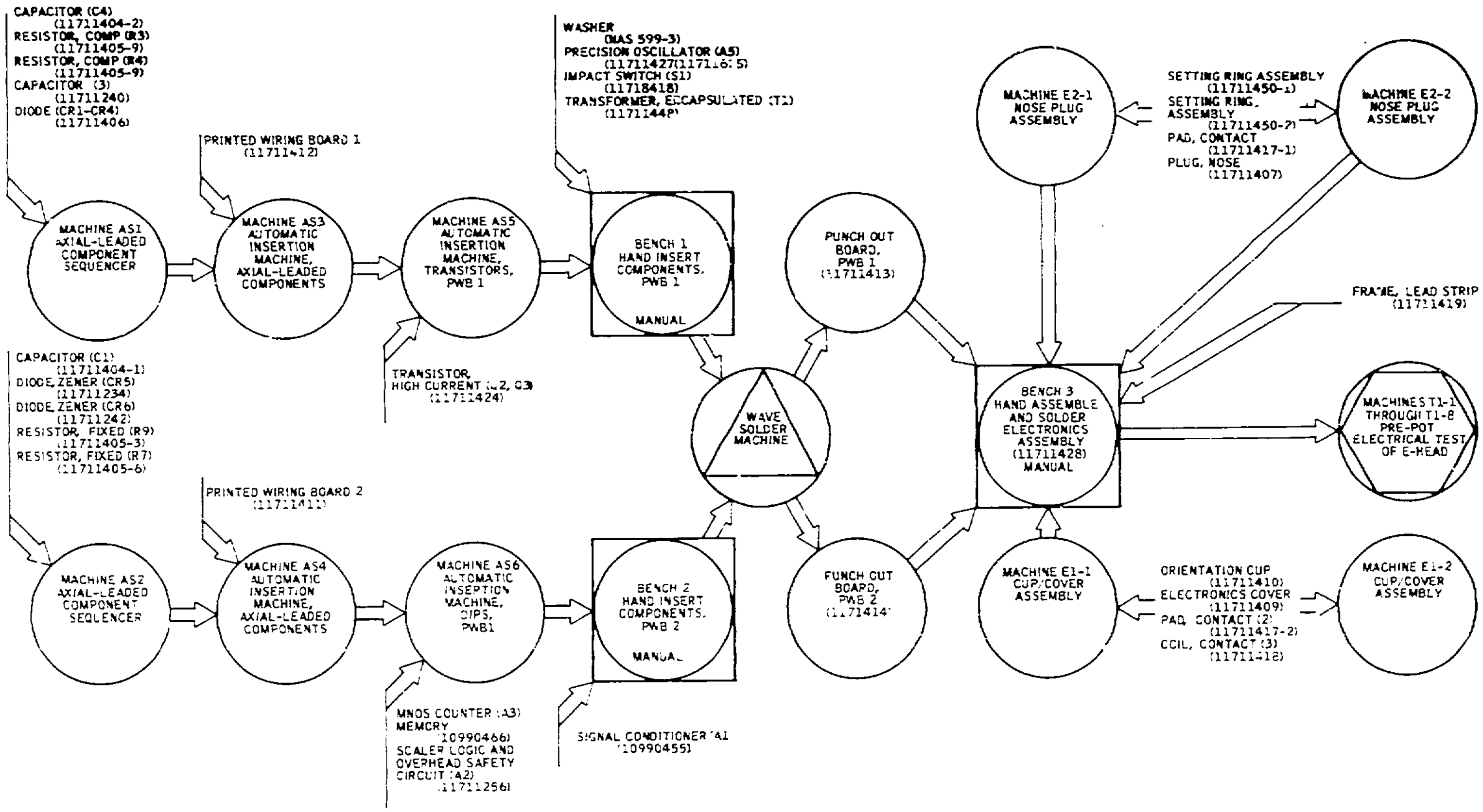


Figure 4. XM587E2/XM724 fuze automated assembly line process flow diagram, part A.

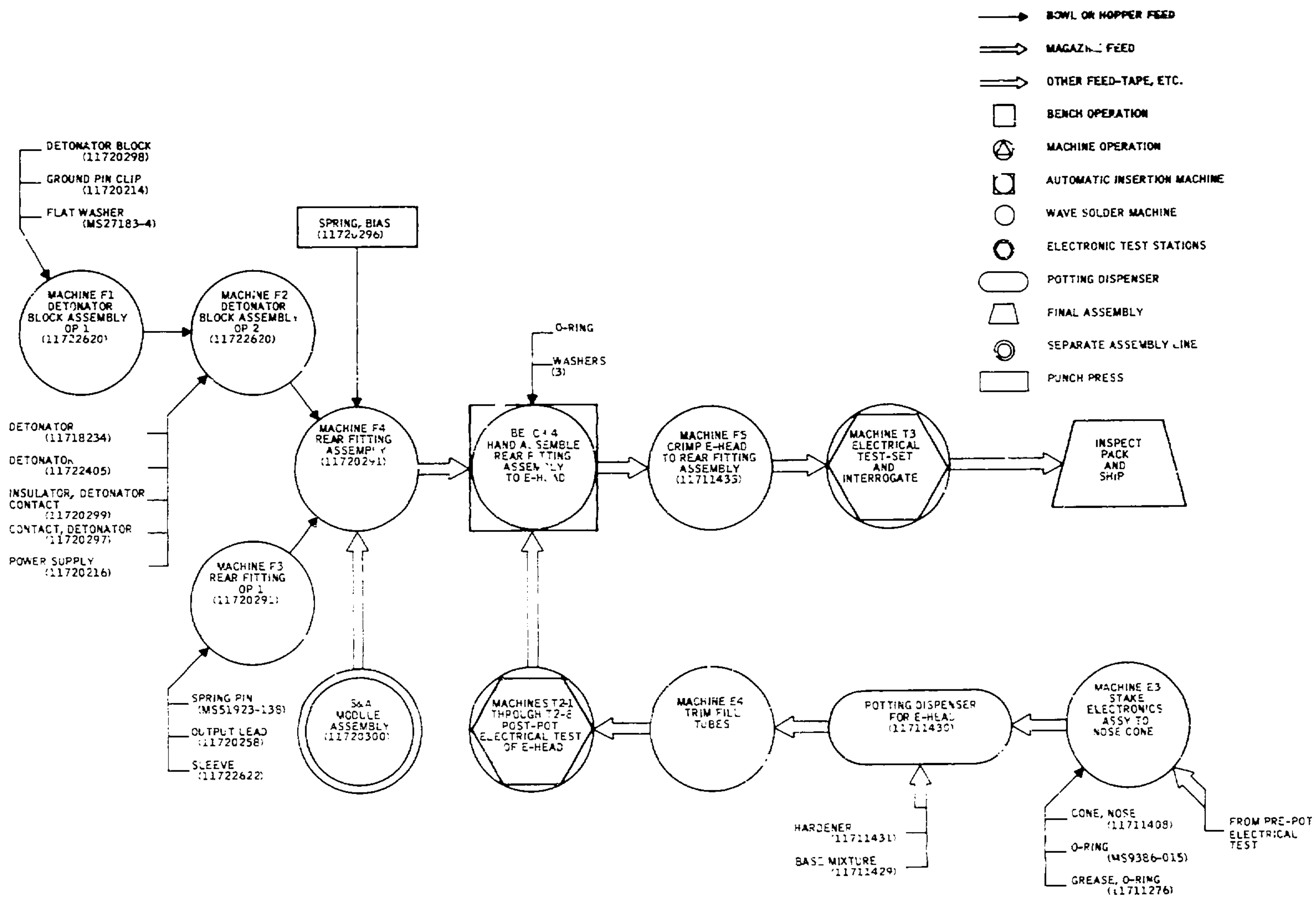


Figure 5. XM587E2/XM724 fuze automated assembly line process flow diagram, part B.

The wave soldering operation is accomplished on a standard continuous wave soldering machine.

The automated assembly operations are accomplished on dial-index automated assembly machines similar to those described for S&A module automated assembly operations. The nose plug assembly and the electronics cup /cover assembly are assembled with dial-index automated assembly machines. The electronics subassembly is assembled by a manual operation. This has been defined as a manual operation at the present time because of the complexity of the assembly operation.

Once the electronics subassembly is assembled, it goes through the automated test station and is then pressed and staked into the nose cone. The potting mixing and dispensing is an automated operation with an oven cure prior to trimming the fill tubes. The electronics and nose cone assembly lot sample tests are removed at this point.

S&A modules from an accepted lot are assembled along with the other required parts to fabricate the rear fitting assembly. At this point, the samples for rear fitting assembly lot sample tests are removed.

The electronics nose cone assembly and rear fitting assembly are combined in a manual operation and the two assemblies are crimped together. The finished fuzes are tested and are then ready for packaging.

2.5 General Automated Assembly Machine Requirements

The machines and equipment w· · be designed to comply with Occupational Safety and Health Act (OSHA) requirements. Moving machinery, pinch points, and impact points which may cause operator injury will be shielded.

All stations handling or working with explosive components will be properly barricaded to funnel upward. Barricades will be equipped with doors for operator entrance and switches to stop the machine when the door is opened. The design goal for maximum machine and equipment noise will be to meet OSHA requirements.

Feeder bowls will be shrouded, as required, to ensure compliance with noise level requirements.

The machines and equipment will be painted. Exposed metal surfaces other than bearing, sliding, or work surfaces will be plated or painted.

Stress-relieved castings will be utilized for the machine bases to achieve compact, rigid construction. The main drive for the machines will include a closed-cam, dial-index system with a reciprocating, vertical-motion tooling plate and a mechanical overload breakaway that prevents machine damage if a jammed dial occurs. The dial position will be accurately maintained with a shotpin locator. All machines will include a lubricating system with provisions to lubricate major pivot points and a handwheel to permit manual machine operation.

All feed stations will be designed to feed at a rate in excess of machine requirements. Probes which determine part presence and position will follow each feed station. Although only parts meeting drawing-specified tolerances are to be run in the machine, the feed system will be designed to protect the stations and the machine itself from malformed or damaged parts.

If loss of power, loss of memory, or circuit failure occurs, the acceptable assemblies will be ejected at the reject station. Defective assemblies will not be ejected to the accept station, thus ensuring a fail-safe system.

Machine air drive or control systems will include necessary air filters, cylinders with flow controls, regulators, oilers, surge tanks, etc. All elements of the air systems will be rated for 150 psi minimum. Each machine will include a minimum air pressure safety switch and an air brake clutch-coupled reducer to the main drive motor.

All electrical components and wiring used on the machines and equipment will comply with the specifications and National Electrical Code (NEC) requirements. Because the machines for each fuze assembly operation are different in makeup, a varying degree of memory will be used in each control system. This will ensure better quality, less parts handling, and a minimum of part loss. Where the full memory control system is used, all consecutive stations following a detected defective unit will be locked out so that no further work is performed on the defective unit.

Each machine will include a push button control panel located for operator convenience. The control panel will include motor start and stop, manual mode, automatic mode, emergency stop, and individual reset buttons for individual stations where necessary.

3. S&A MODULE AUTOMATED ASSEMBLY LINE

3.1 General Description

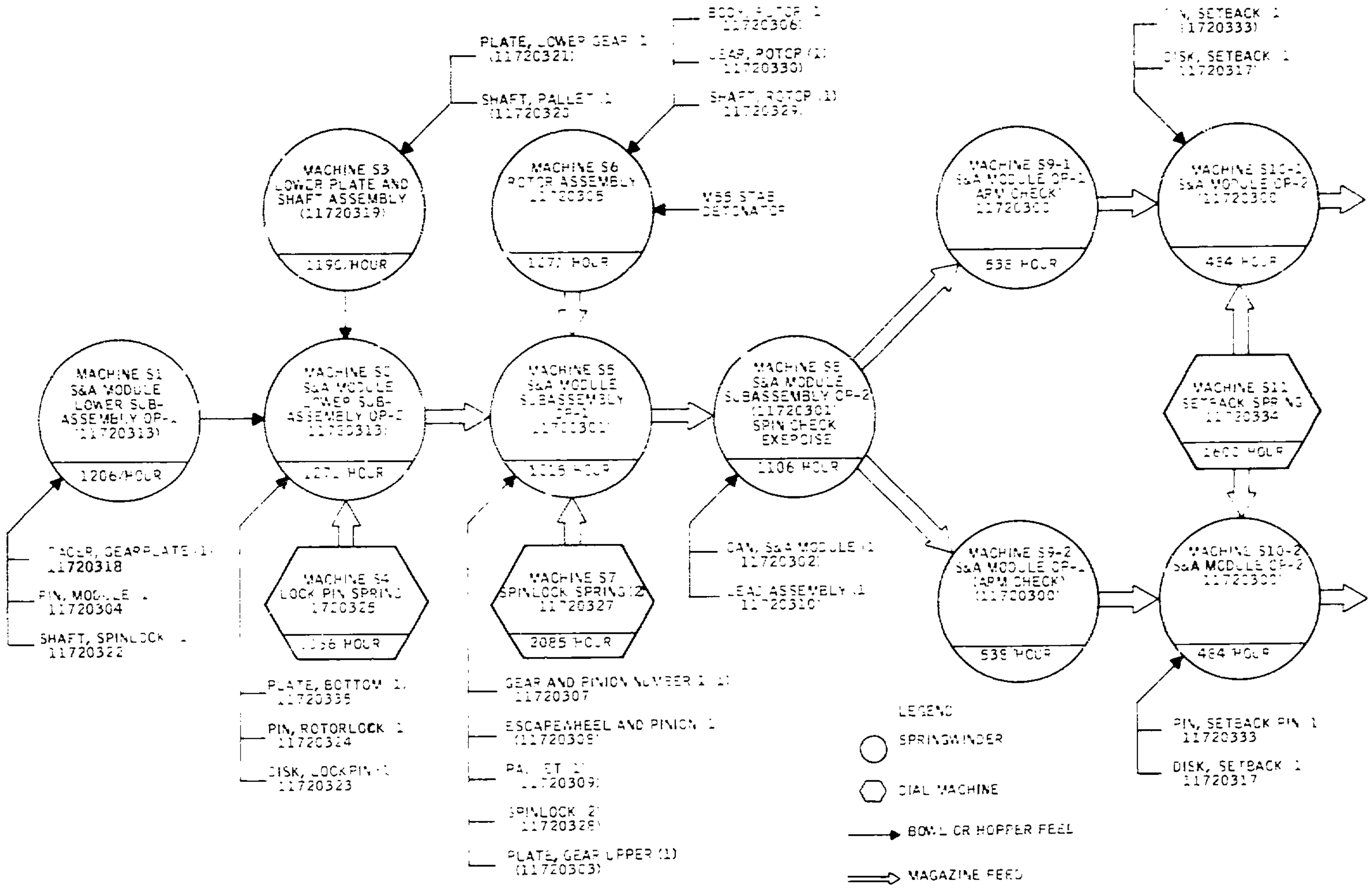
The automated assembly line for the XM587E2/XM724 fuze S&A module requires 10 automated assembly machines and three spring winders. This quantity of machines will be required to establish a production line capable of an output of 100,000 units per month on a 1-8-5 production basis and 290,000 units per month on a 3-8-7 production basis. These outputs will be accomplished after the continuous production of 1,000,000 units at a rate consistent with the stage of development of the line.

Figure 6 is a process flow diagram showing the machines required and the flow of parts and subassemblies through the line including the minimum required production cycle rate for each machine. Duplicates of machines S9 and S10 will be required to maintain the projected production rate. The output of machines S9 and S10 is limited due to the spin time required during the arm/non-arm check.

The legend on the flow diagram depicts the proposed parts handling mechanisms; e.g., parts will be hopper or bowl fed into machine S1. This subassembly (S&A module lower subassembly) will be ejected to a suitable container and subsequently hopper or bowl fed into machine S3. The subassembly from machine S2 will be ejected to a special magazine for subsequent feeding into machine S5. An assembly breakdown of parts assembled by machines S1 through S5 is shown in figure 7.

The spring winding machines will produce springs and feed them to suitable stick magazines. Magazines allow stocking and lot buildup of springs independent of the subsequent assembly operation. Production from spring winders usually exceeds that of automated assembly machines as shown in the flow diagram. Note that the spinlock spring from machine S7 is a two-user in machine S5, but one spring winder is capable of maintaining the projected production rate. Additionally, the two S10 machines can be stocked with springs from the spring winder (machine S11).

The output of S&A modules from the S10 machines will be ejected to special magazines fabricated from either roll formed sheet metal or extruded aluminum. These magazines will provide a safe storage and transfer vehicle until the S&A modules are required for installation in the rear fitting assembly. An assembly breakdown of parts assembled in machines S8 and S10 is shown in figure 8.



NOTE: PRODUCTION RATE SHOWN IS MINIMUM DESIGN CYCLE RATE REQUIRED FOR 100,000 UNITS PER MONTH ON A 1-8-5 PRODUCTION BASIS.

Figure 6. XM587E2/XM724 fuze S&A module automated assembly line process flow diagram and producion rate

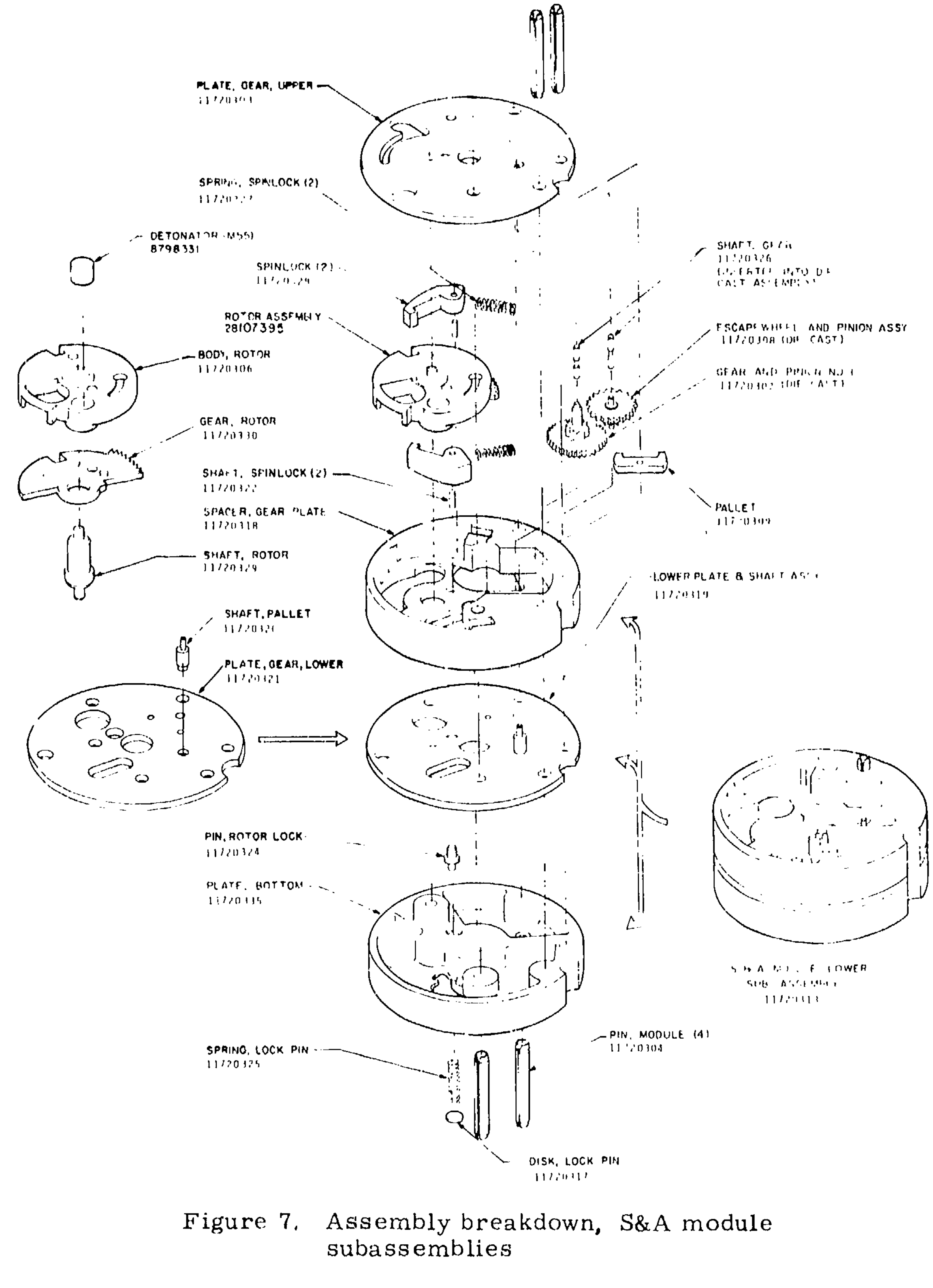


Figure 7. Assembly breakdown, S&A module subassemblies

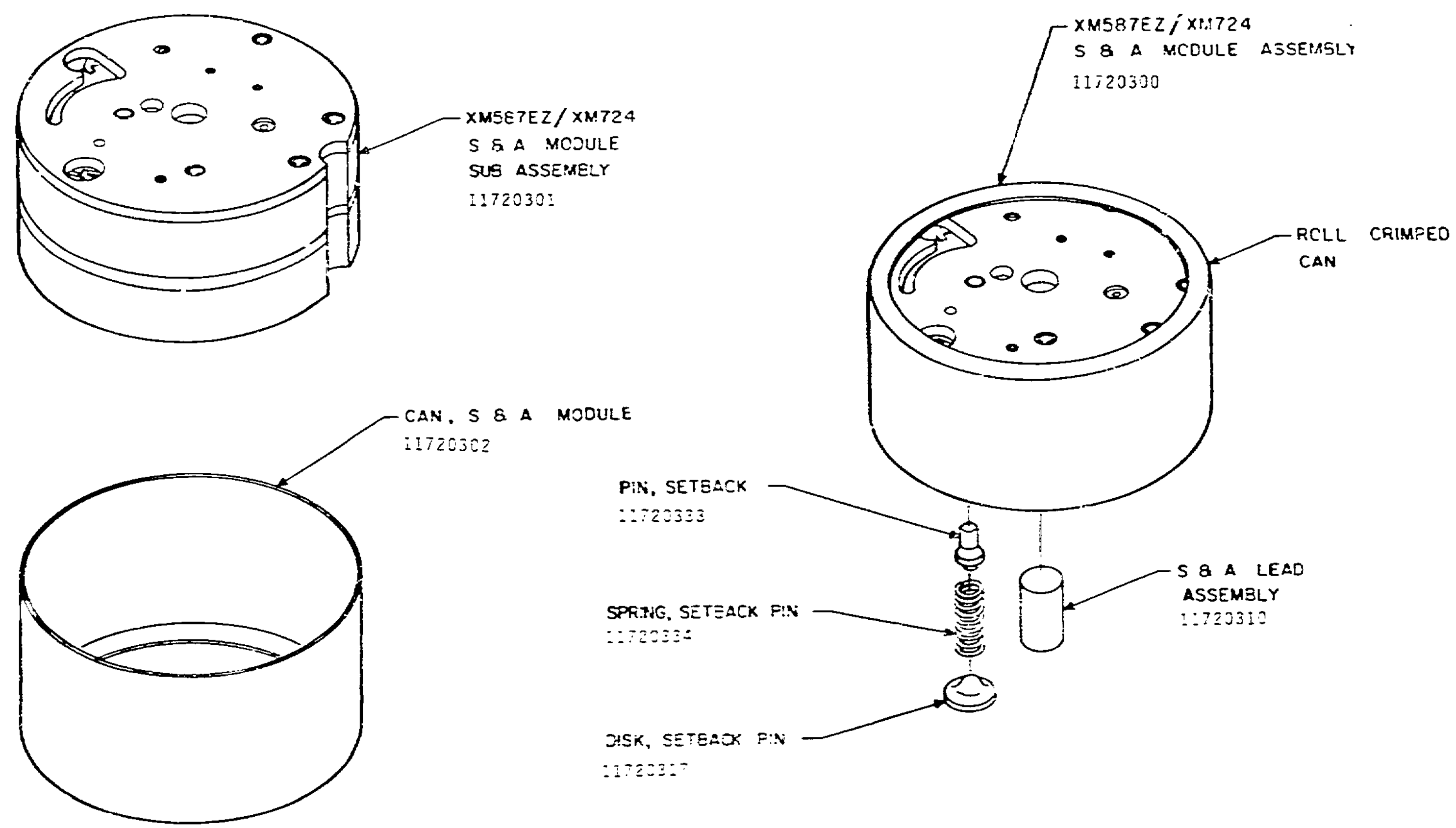


Figure 8. Assembly breakdown, S&A module assembly

Individual descriptions and a dial schematic layout of each proposed machine are included in the following pages. The automated assembly machine dial schematics show the proposed number of nests and the work being accomplished at each nest, plus the idle and inspection stations. In addition to the inspections performed on the machines, additional quality conformance inspections will be conducted as noted in the individual descriptions. Inspection stations are identified as follows:

- □ identifies a requirement listed in the applicable specification control drawing.
- △ identifies features inspected for contractor control.

3.2 Individual Automated Assembly Machine Descriptions

3.2.1 Machine S1 - S&A Module Lower Subassembly (11720313) Operation 1 --

3.2.1.1 Operations -- Machine S1 stakes and probes the spinlock spring pockets as well as assembling the two spinlock shafts and the four module pins to the spacer gear plate. Two of the module pins (shown in drawing 11720313) are assembled on this machine to relieve the complexity on machine S5. All four module pins and two shafts are checked for presence and position. See figure 9.

3.2.1.2 Parts Assembled --

Item	Part Number
Gear plate spacer	11720318
Module pins (4)	11720304
Spinlock shafts (2)	11720322

3.2.1.3 Lot Sample Inspection -- A lot sample inspection is planned for checking spinlock spring pocket size as shown in drawing 11720318.

3.2.1.4 Next Operation -- Machine S2 - S&A Module Lower Subassembly Operation 2.

3.2.2 Machine S2 - S&A Module Lower Subassembly (11720313) Operation 2

3.2.2.1 Operations -- Machine S2 assembles the bottom plate, lower plate and shaft assembly, lower subassembly (from operation 1), rotor lock pin and lock pin spring as well as blanking and staking the lock pin disk. All piece parts are probed for presence and position

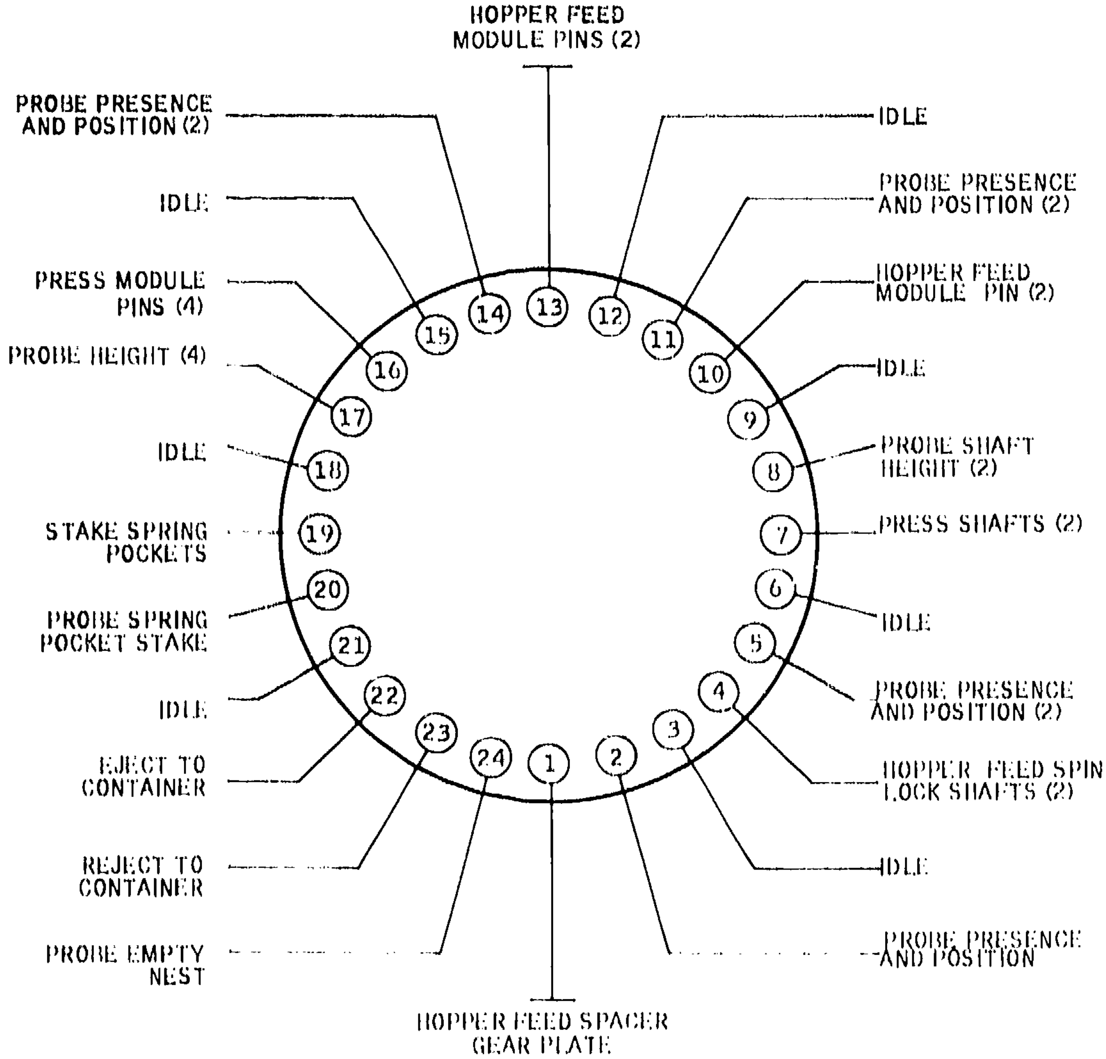


Figure 9. Dial schematic, machine S1 - S&A module lower subassembly operation 1

and the lock pin disk is checked for flush or below. See figure 10.

3.2.2.2 Parts Assembled --

Item	Part Number
Bottom plate	11720335
Lower plate and shaft assembly	11720319
Lower subassembly (operation 1)	11720313
Rotor lock pin	11720324
Lock pin spring	11720325
Lock pin disk	11720317

3.2.2.3 Lot Sample Inspection -- A lot sample inspection is planned for checking the height of the module pins above the spacer surface as shown in drawing 11720313.

3.2.2.4 Next Operation -- Machine S5 - S&A Module Subassembly Operation 1.

3.2.3 Machine S3 - Lower Plate and Shaft Assembly (11720319) --

3.2.3.1 Operations -- Machine S3 assembles and stakes the pallet shaft to the lower gear plate. After a 2-pound pushout force is applied, the 0.177-inch maximum height of the pallet shaft is checked. This machine is double tooled with dual nests, but it could be built with single tooling with the option of adding the second set of tooling. See figure 11.

3.2.3.2 Parts Assembled --

Item	Part Number
Lower gear plate	11720321
Pallet shaft	11720320

3.2.3.3 Lot Sample Inspection -- None.

3.2.3.4 Next Operation -- Machine S2 - S&A Module Lower Subassembly Operation 2.

3.2.4 Machine S5 - S&A Module Subassembly Operation 1 (Gear Train - 11720301) --

3.2.4.1 Operations -- Machine S5 assembles the parts listed below to the S&A module subassembly. The assembly process includes

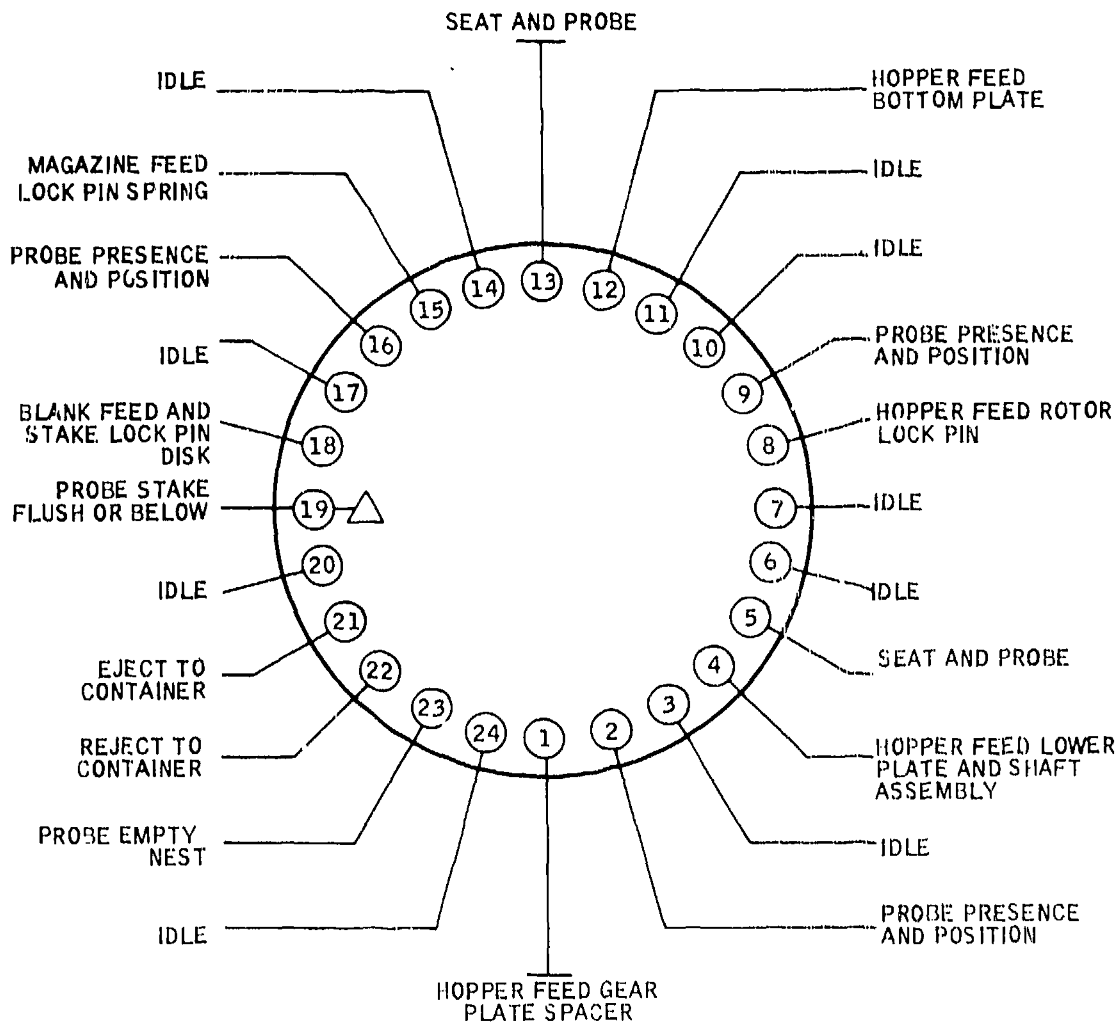


Figure 10. Dial schematic, machine S2 - S&A module lower subassembly operation 2

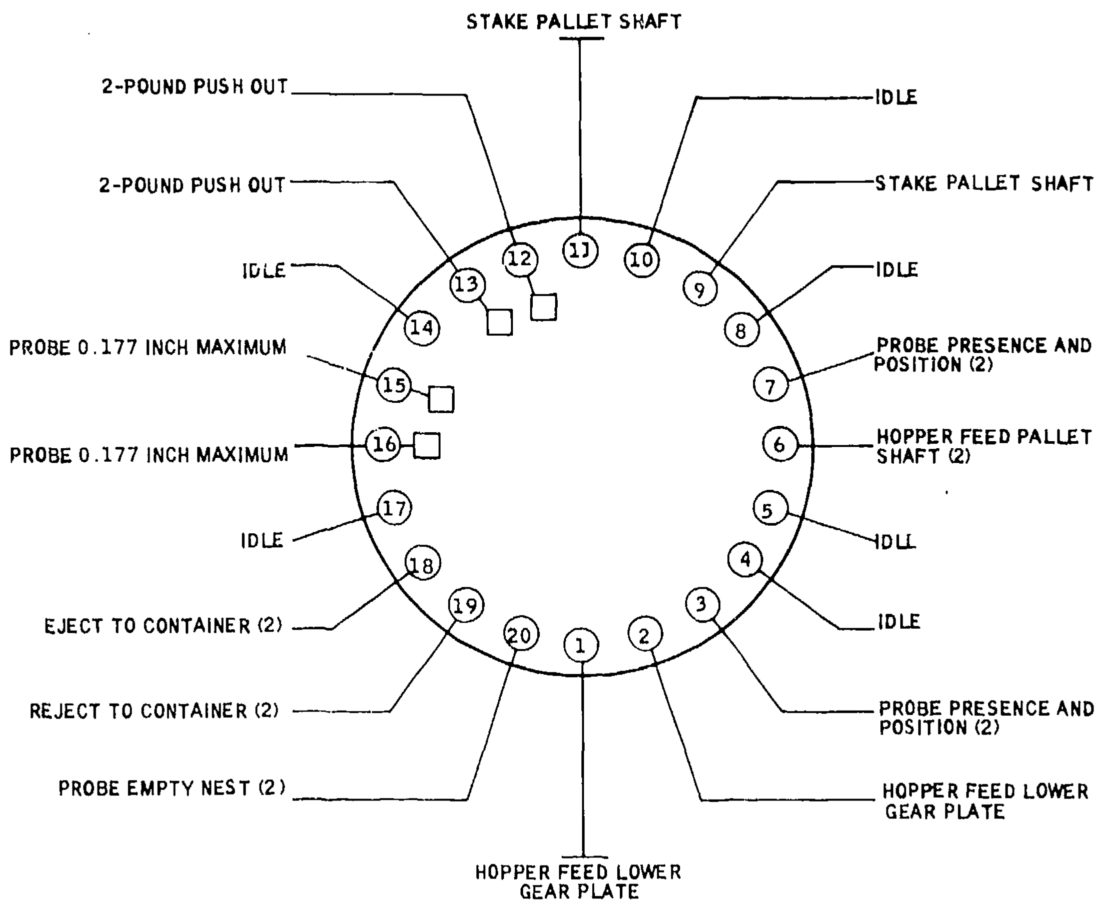


Figure 11. Dial schematic, machine S3 - lower plate and shaft assembly

inspection of S&A module height (0.532 inch maximum) and winding of the rotor to the non-arm position. See figure 12.

3.2.4.2 Parts Assembled --

Item	Part Number
Pallet	11720309
Escape wheel and pinion assembly	11720328
Gear and pinion number 1	11720307
Rotor assembly	11720305
Spinlocks (2)	11720328
Spinlock springs (2)	11720327
Gear upper plate	11720303

3.2.4.3 Lot Sample Inspection -- None.

3.2.4.4 Next Operation -- Machine S8 - S&A Module Subassembly Operation 2.

3.2.5 Machine S6 - Rotor Assembly (11720305) --

3.2.5.1 Operations -- Machine S6 inserts and stakes the M55 detonator into the rotor body. A 1-pound pushout test is then applied to the M55 detonator. The rotor shaft and rotor gear are then assembled to the rotor body and the rotor gear is staked in position. Besides probing for presence and position of all parts, the 0.053-inch minimum and 0.237-inch maximum heights are also checked. See figure 13.

3.2.5.2 Parts Assembled --

Item	Part Number
Rotor body	11720306
Rotor gear	11720330
Rotor shaft	11720329
M55 detonator	8298331

3.2.5.3 Lot Sample Inspection -- A lot sample inspection is planned for roll gear data per drawing 11720305.

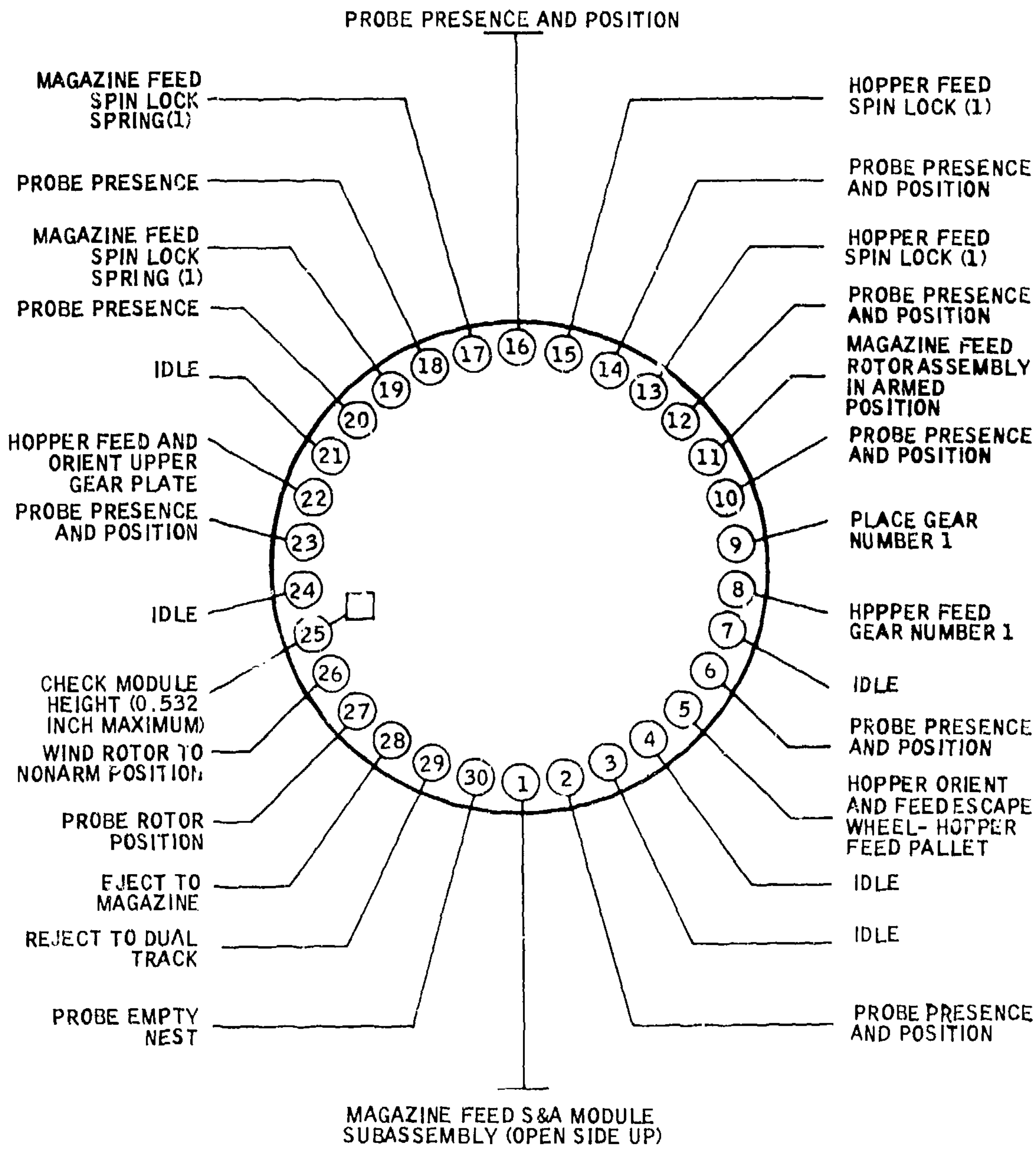


Figure 12. Dial schematic, machine S5 - S&A module subassembly operation 1 (gear train)

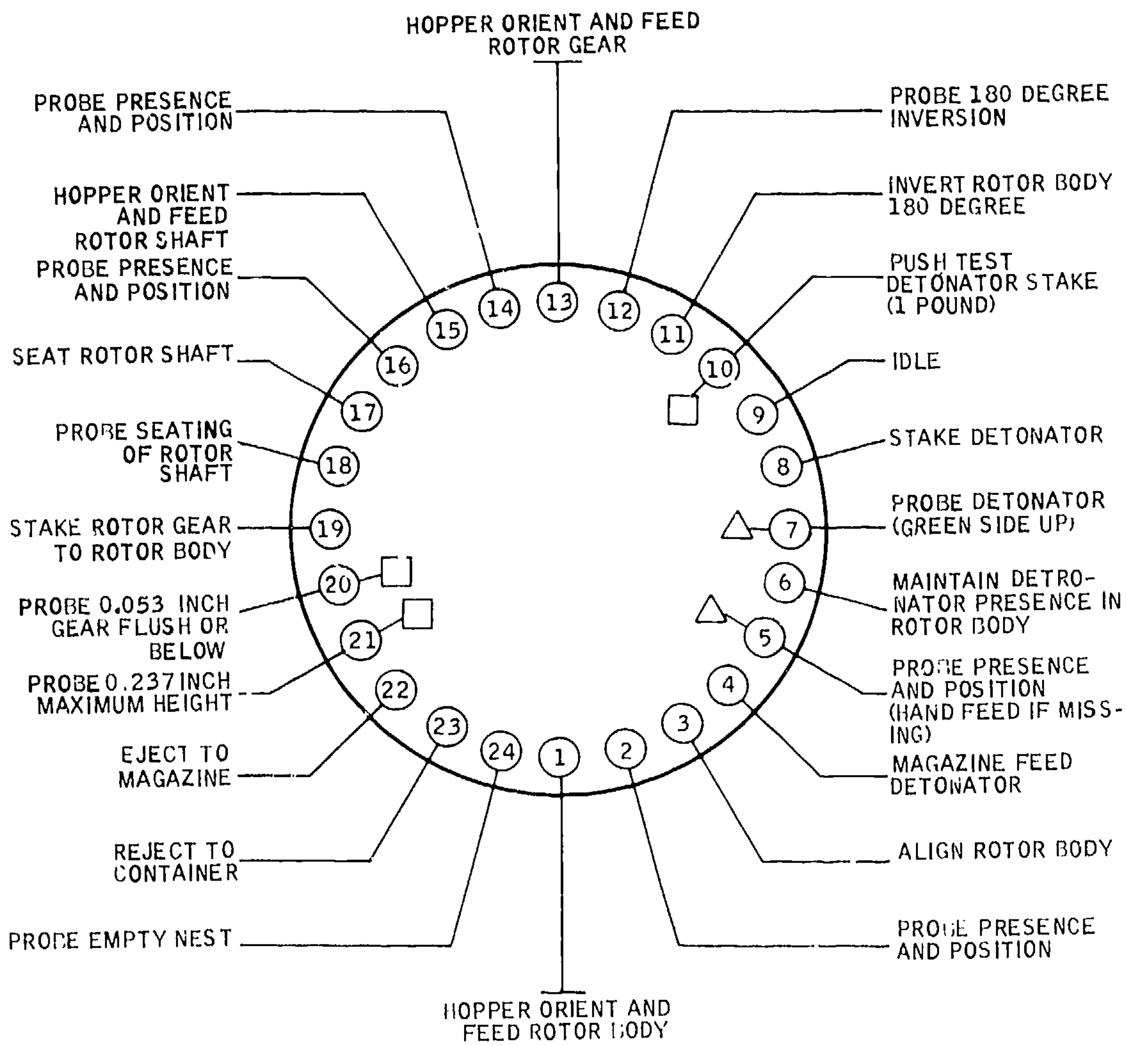


Figure 13. Dial schematic, machine S6 - rotor assembly

3.2.5.4 Next Operation -- Machine S5 - S&A Module Subassembly Operation 1.

3.2.6 Machine S8 - S&A Module Subassembly, Operation 2 (Lead Cup - 11720300 and 11720301) --

3.2.6.1 Operations -- Machine S8 assembles the parts listed below to the S&A module subassembly. The assembly operation also includes the following:

- Spin exercise the S&A module at 5000 rpm.
- Probe for armed position.
- Probe for lead cup inversion.
- Minimum can length.

See figure 14.

3.2.6.2 Parts Assembled --

Item	Part Number
S&A module can	11720302
Lead cup	11720310

3.2.6.3 Lot Sample Inspection -- A lot sample inspection is planned for checking the S&A module outside diameter in accordance with drawing 11720300 and a visual check is planned for roll crimp workmanship.

3.2.6.4 Next Operation -- Machine S9 - S&A Module Assembly Operation 1.

3.2.7 Machine S9 - S&A Module Assembly Operation 1 (Arm Check - 11720300) --

3.2.7.1 Operations -- Machine S9 performs the following inspection operations:

- Spin exercise the S&A module at 5000 rpm.
- Arm check at 1700 rpm.
- Non-arm check at 1100 rpm.

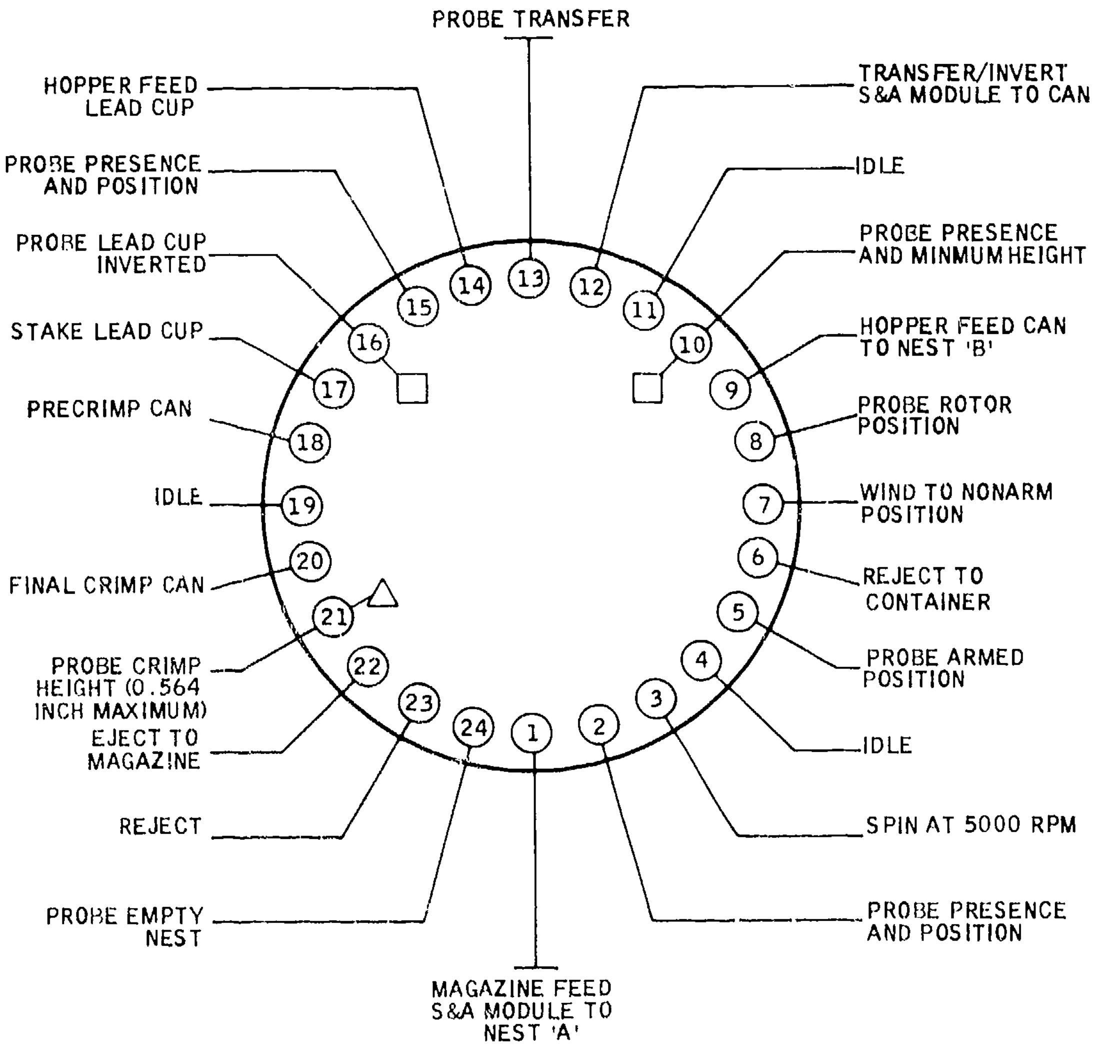


Figure 14. Dial schematic, machine S8 - S&A module subassembly operation 2 (lead cup)

Each of the above operations is monitored by inspection probes which inspect proper rotor position. Reject stations after each of the inspection stations remove nonconforming assemblies from the machine. See figure 15.

3.2.7.2 Parts Assembled -- None.

3.2.7.3 Lot Sample Inspection -- The microprocessor machine controller shall accumulate go/no-go data on all arm and nonarm checks. These data will be transferred automatically to a magnetic tape and recorded as X number of rejects per Y number of tests performed. Means will be provided to insert the date and lot number. This will probably be done by a small keyboard mounted on the controller.

3.2.7.4 Next Operation -- Machine S10 - S&A Module Assembly Operation 2.

3.2.8 Machine S10 - S&A Module Assembly Operation 2 (Setback Pin - 11720300) --

3.2.8.1 Operations -- Machine S10 assembles the parts listed below to the S&A module assembly. The assembly operation includes inspection of setback pin stake flush to below and freedom of movement and a spin check at 5000 rpm. See figure 16.

3.2.8.2 Parts Assembled --

Item	Part Number
Setback pin	11720333
Setback pin disk	11720317
Setback pin spring	11720334

3.2.8.3 Lot Sample Inspection -- A lot sample inspection is planned for checking the setback disk stake integrity.

3.2.8.4 Next Operation -- None.

3.2.9 Spring Winders -- The following spring winding (coiling) machines will be required for the S&A module automated assembly line:

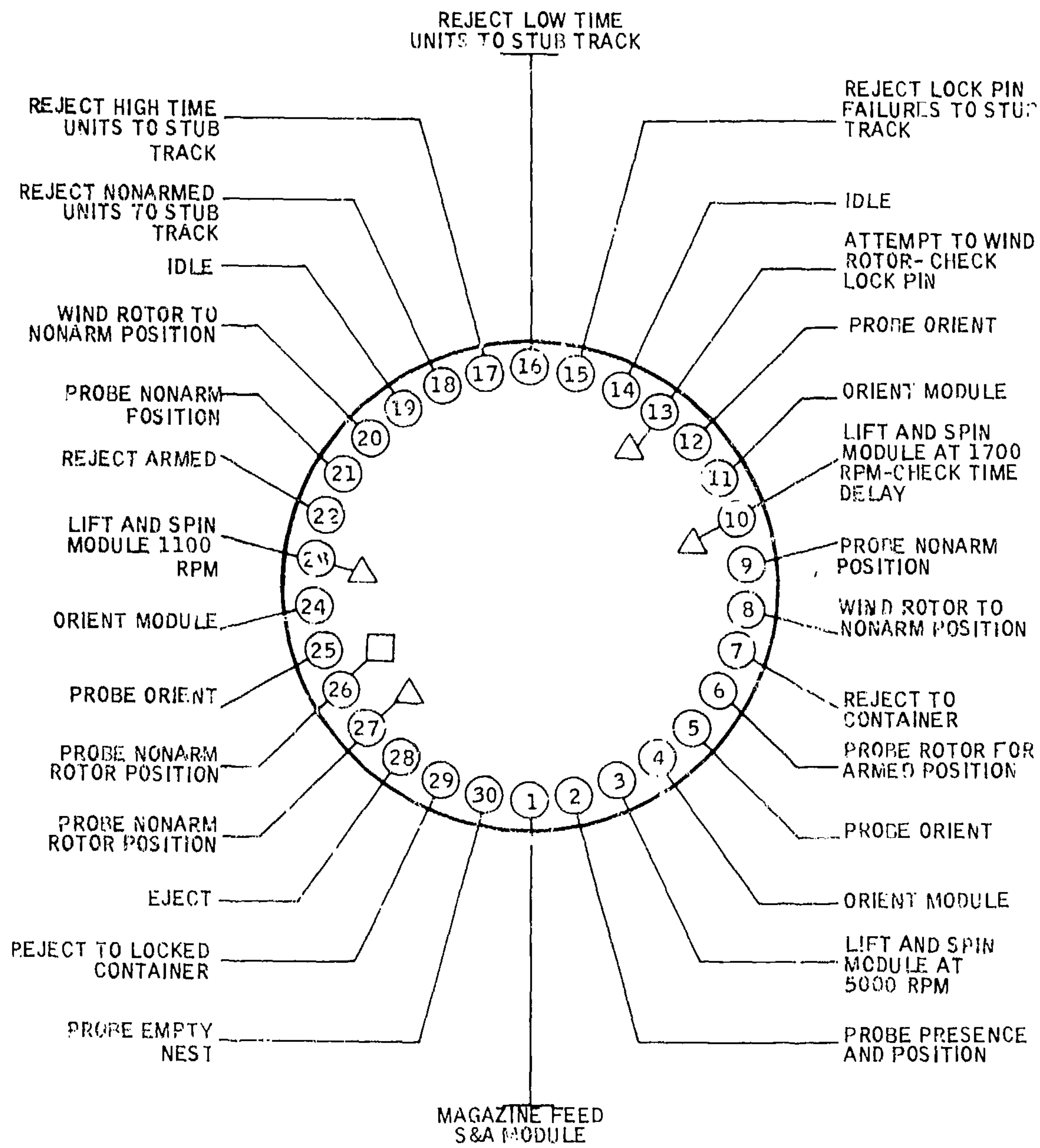


Figure 15. Dial schematic, machine S9 - S&A module assembly operation 1 (arm check)

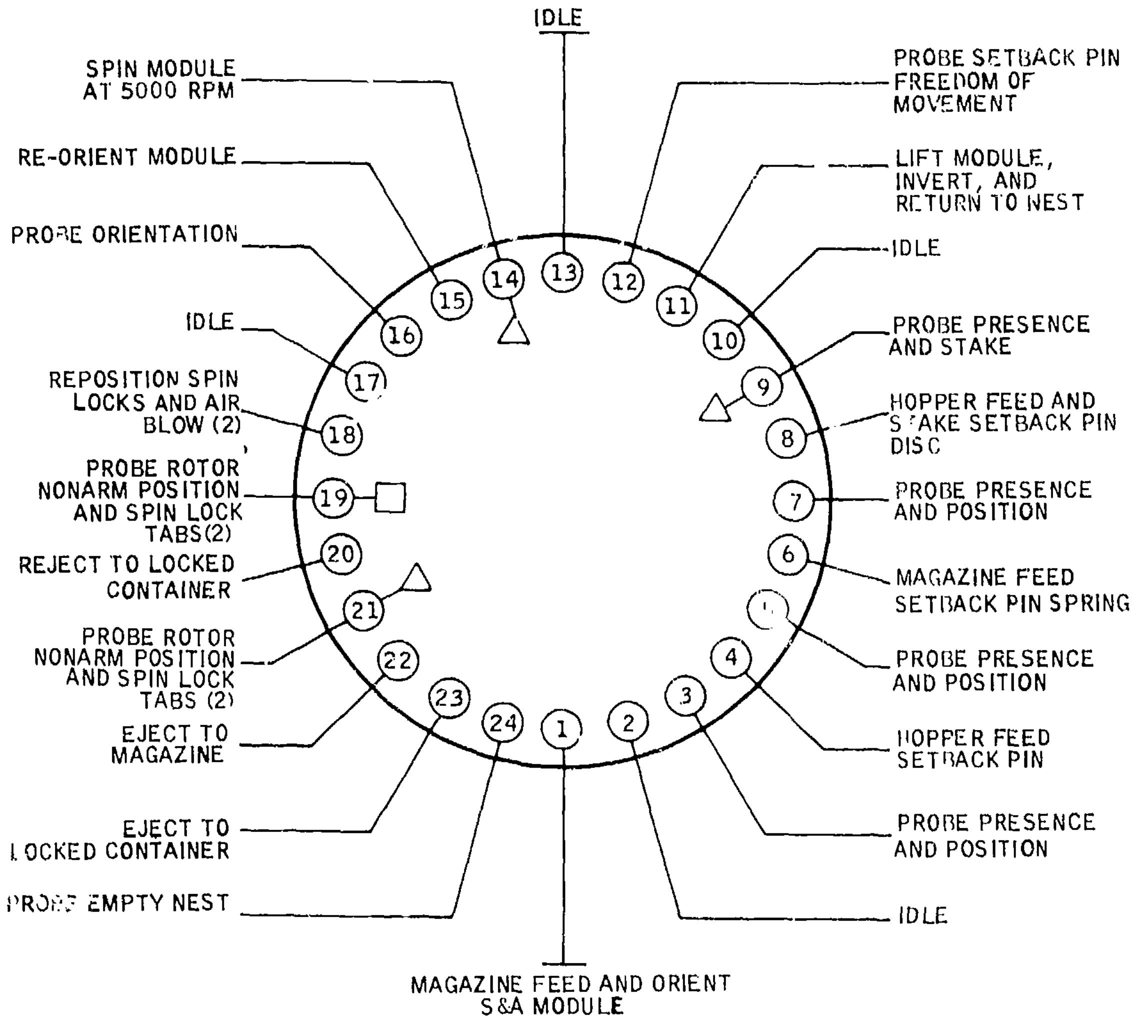


Figure 16. Dial schematic, machine S10 - S&A module assembly operation 2 (setback pin)

- Machine S4 - Lock pin spring (figure 17).
- Machine S7 - Spinlock spring (figure 18).
- Machine S11 - Setback spring (figure 19).

Each spring winder will manufacture the spring and place it in a stock magazine for use in a subsequent automated assembly machine as shown in the flow chart (figure 6). The spring winder production rate will be high enough so that one spring winder could manufacture springs to feed several automated assembly machines. Magazines provide a reliable storage mechanism while maintaining spring quality through subsequent operations such as pickup and feed to the proper assembly.

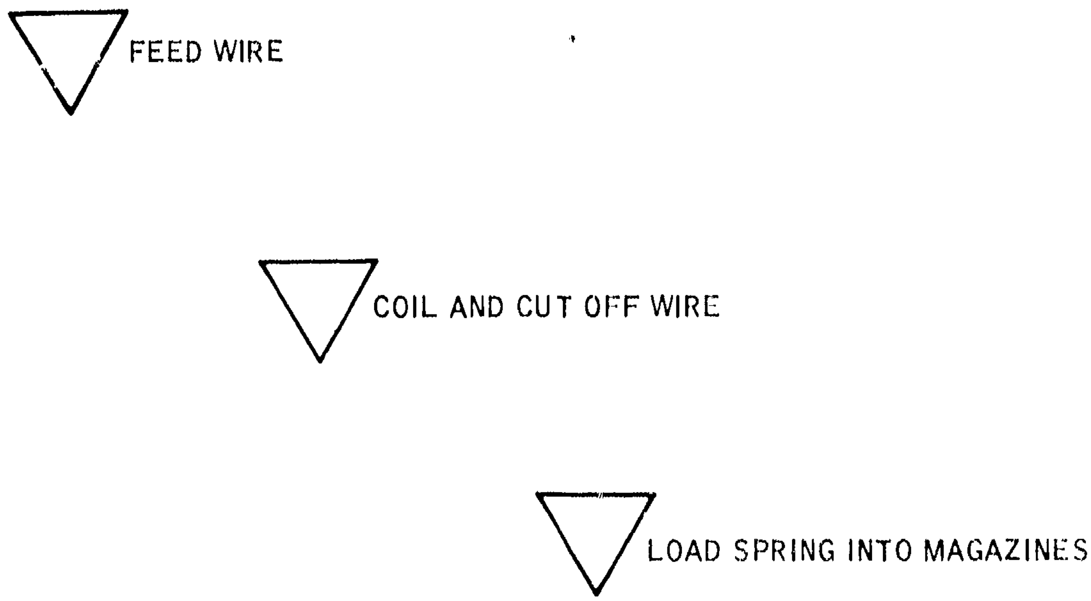


Figure 17. Station schematic, machine S4 - S&A module lock pin spring

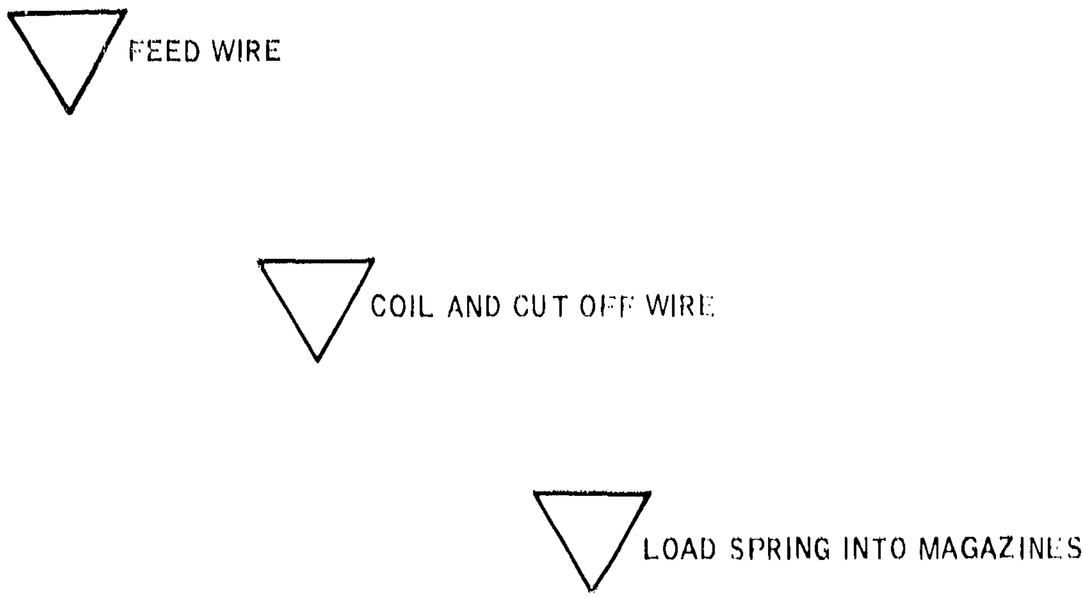


Figure 18. Station schematic, machine S7 - S&A module spinlock spring

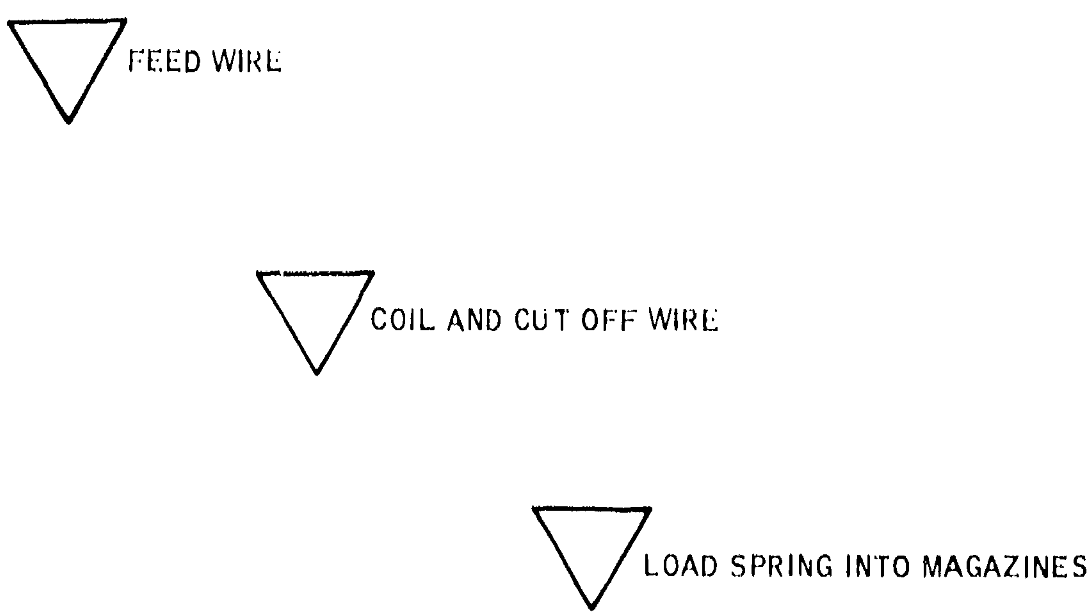


Figure 19. Station schematic, machine S11 - S&A module setback spring

4. FUZE AUTOMATED ASSEMBLY LINE

4.1 General Description

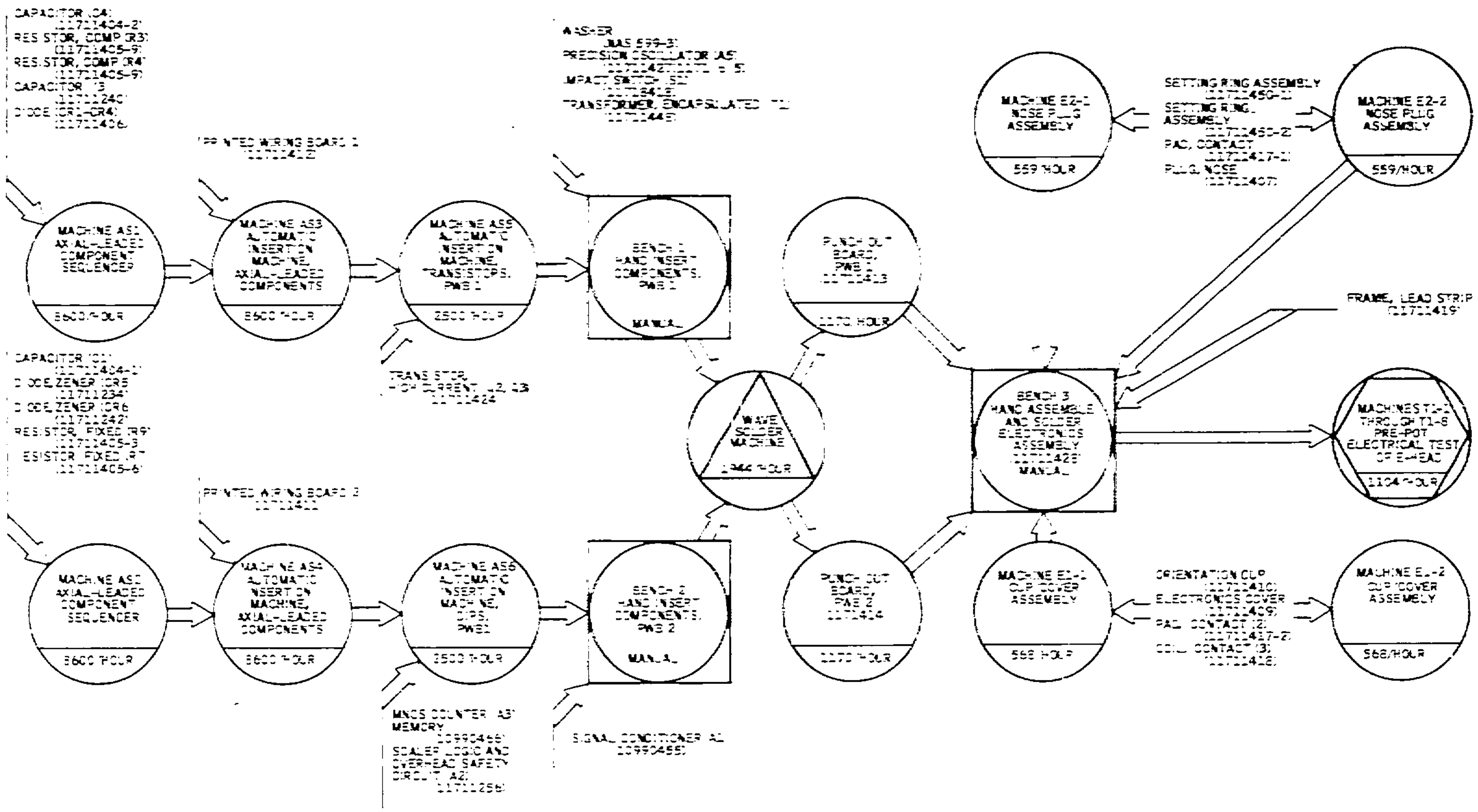
The mechanized line for assembly, inspection, and testing of the XM587E2/XM724 electronic time fuzes (less S&A modules) will include the following major stations:

Equipment	Number Required
Automatic component insertion equipment	
• Axial-leaded component sequencers	2
• Axial-leaded component inserters	2
• Transistor inserter	1
• Dual in-line package (DIP) integrated circuit sequencer/inserter	1
Wave soldering machine	1
Printed wiring board punch out stations	2
Automated assembly machines (Honeywell dial index)	11
Electrical test stations	3
Automated encapsulation system	1
Crimping machine	1

This quality of machines (stations) will be required to establish an automated assembly line capable of an output of 100,000 units per month on a 1-8-5 production basis and 290,000 units per month on a 3-8-7 production basis. These outputs will be accomplished after the continuous production of 1,000,000 units at a rate consistent with the stage of development of the line.

In addition to the equipment listed above, there will be four manual assembly stations. These operations are such that mechanization is economically impractical with the present baseline fuze designs.

Figures 20 and 21 are process flow diagrams showing the equipment required and the flow of parts and subassemblies through the



NOTE. PRODUCTION RATE SHOWN IS MINIMUM DESIGN CYCLE RATE REQUIRED FOR 100 000 UNITS PER MONTH ON A 1-8-5 PRODUCTION BASIS.

Figure 20. XM587E2/XM724 fuze automated assembly line part A process flow diagram and production rate

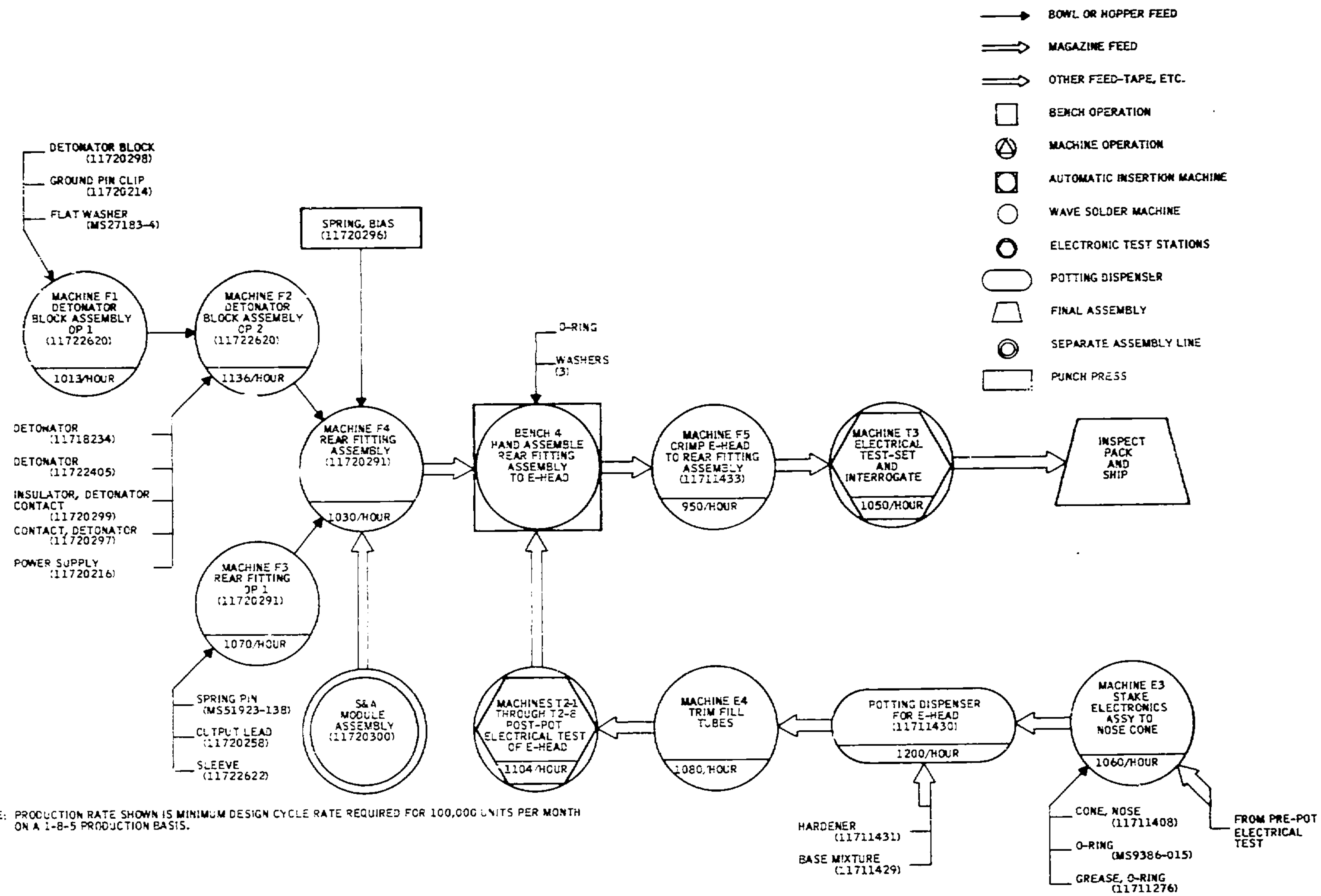


Figure 21. XM587E2/XM724 fuze automated assembly line part B process flow diagram and production rate

automated assembly line, including the minimum required production cycle rate for each machine.

Machines F1 through F4 are typical Honeywell-designed dial-index automated assembly machines. Machine F5 is a commercially-available hydraulic press with a dial-index table. It will be tooled especially for the crimping of the electronics and nose cone assembly (E-head) to the rear fitting assembly.

Machines E1 through E4 are also Honeywell-designed dial-index automated assembly machines. Duplicates of machine E1 (electronic cover and orientation cup assembly) and machine E2 (setting ring and plug assembly) are required to meet the proposed production rate. The slower indexing rate on these machines is due to the size and shape of the electrical components; i.e., contact pad, contact coil, and setting rings.

A fuze pictorial diagram showing the subassemblies and operations previously discussed is shown in figure 22.

Another major portion of the automated assembly line is the automated component insertion equipment. There are two separate printed wiring boards in the E-head. Therefore, the sequencing and insertion equipment has been set up to handle each of these printed wiring boards separately. One each axial-leaded component sequencer, axial-leaded component inserter, transistor inserter, and printer wiring board punch out station will be required for printed wiring board 1. One each axial-leaded component sequencer, axial-leaded component inserter, DIP integrated circuit sequencer/inserter, and printed wiring board punchout station will be required for printed wiring board 2. Assembly drawings of printed wiring boards 1 and 2 are shown in figures 23 and 24.

The single wave soldering machine will be capable of handling both printed wiring boards. The printed wiring boards will be conveyed through the wave soldering machine as an array of nine boards on a master carrier.

Prior to soldering and printed wiring board punch out from the carrier, there are two manual assembly operations required, one on each board. These manual bench stations will be manned as required to meet the projected production rate. Manual assembly is required because the components being attached do not lend themselves to automated insertion.

After printed wiring board punch out, another manual assembly operation is required to assemble the boards, the electronic cover and

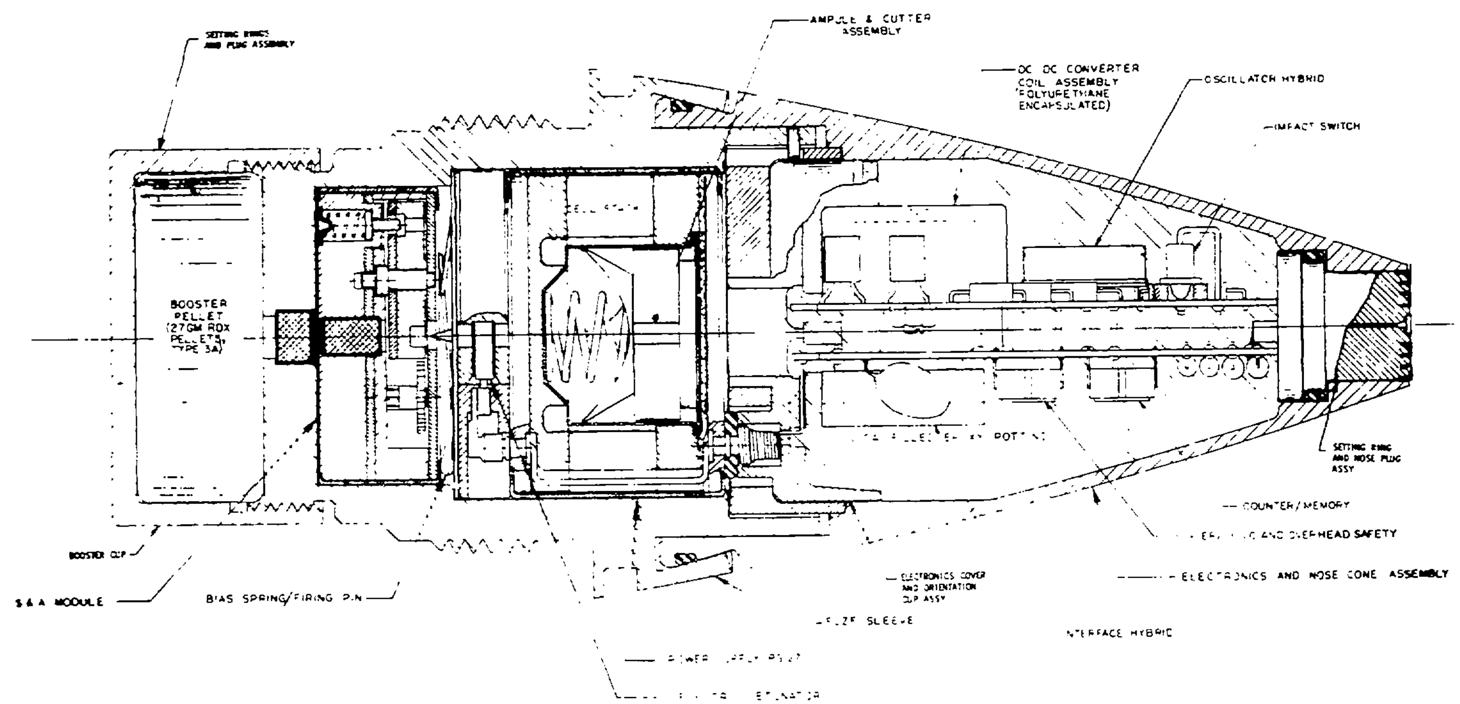


Figure 22. Cutaway view of XM587E2/XM724 fuze

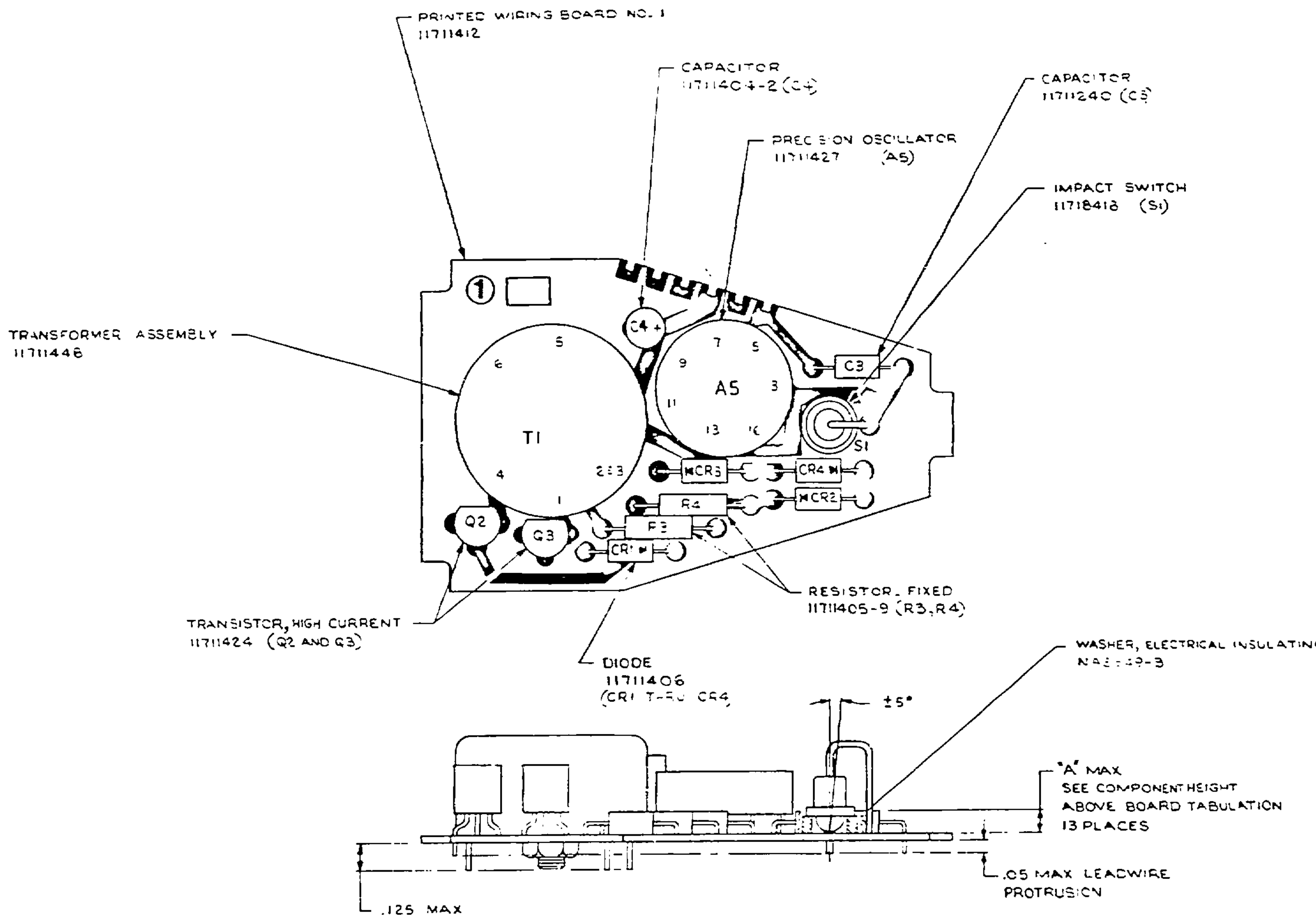
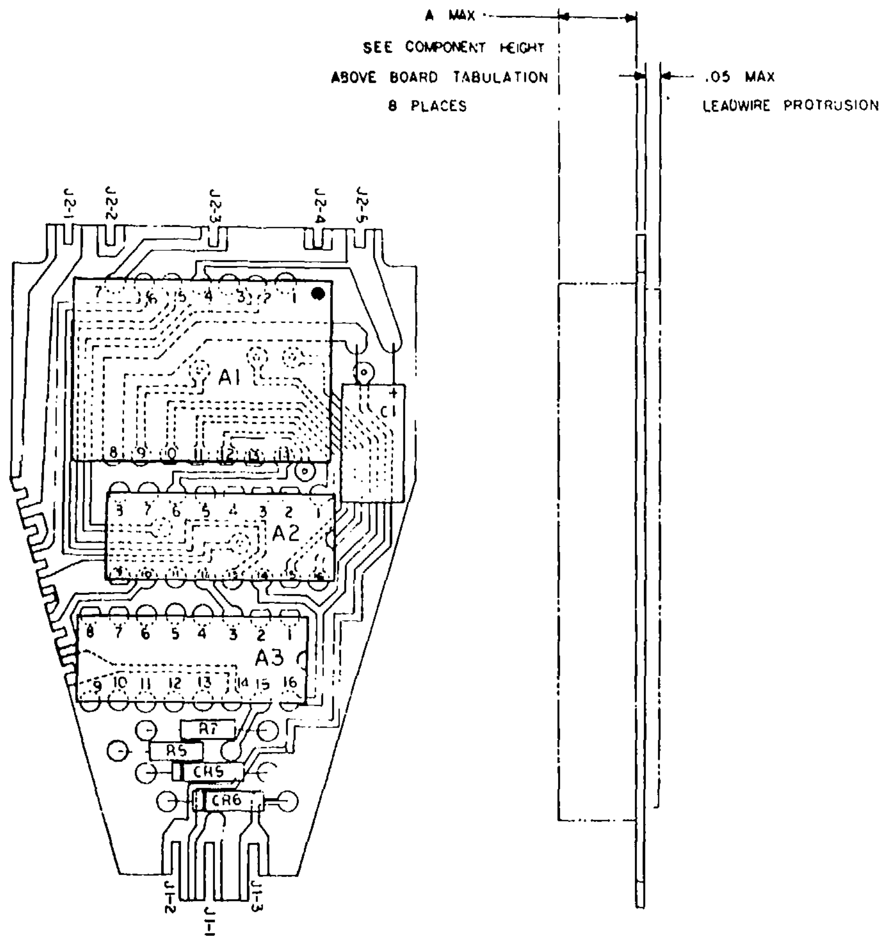


Figure 23. Assembly drawing, fuze printed wiring board 1



LIST OF PARTS			
SYM	DESCRIPTION	PART NO.	QTY
A1	SIGNAL CONDITIONER	10990455	1
A2	MOS SCALER/LOGIC AND OVERHEAD SAFETY	11711256	1
A3	MNOS COUNTER MEMORY	10990466	1
R5	RESISTOR, FIXED	11711405-3	1
R7	RESISTOR, FIXED	11711405-6	1
C1	CAPACITOR, TANTALUM	11711404-1	1
CR5	DIODE, ZENER	11711234	1
CR6	DIODE, ZENER	11711242	1
—	PRINTED WIRING BOARD NO. 2	1171141?	1

Figure 24. Assembly drawing, fuze printed wiring board 2

orientation cup assembly, and the setting ring and nost plug assembly. Manual assembly is required because of fitment and the manipulating of lead wires to obtain the proper electrical path with the printed wiring boards. This manual bench station will be manned as required to meet the projected production rate.

A major item of the automated assembly line is the automated encapsulation system for epoxy encapsulation of the E-head. The requirements of this system are described in later paragraphs. The system, with multiple dispensing heads, will have a capability of meeting the projected production rate.

Electrical testing is planned at three separate operational positions. The first test station will check electronic subassemblies prior to the encapsulation process to allow salvage of high cost components. The second test station on the completed E-head is a contract requirement. The third test station will check the final fuze assembly and set and interrogate it prior to final packing and shipment. Each of these tests will be performed on separate pieces of test equipment using multiple heads to obtain the projected production rate.

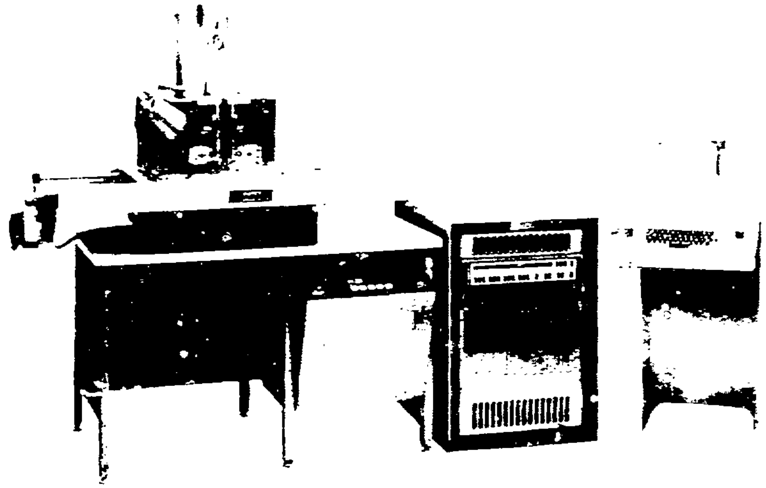
More definitive descriptions of the equipment in the fuze automated assembly line are included in the following pages.

4.2 Automated Electronic Component Sequencing/Insertion Equipment

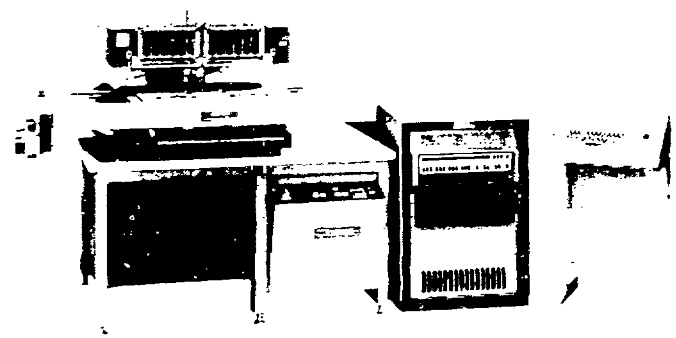
The automated insertion equipment, as shown in the flow diagram of figure 20, is described in the following paragraphs. Photographs of typical automated component insertion equipment are shown in figure 25.

4.2.1 Machines AS1 and AS2 - Axial-Headed Component Sequencers, Printed Wiring Boards 1 and 2 -- The Universal Instruments Model 2583 is a 20-station, axial-leaded component sequencer, expanded by 20 station modules for the sequential taping of axial-leaded components. It sequences axial-leaded components in the insertion sequence chosen (i.e., programmed) by removing components from taped reels and taping the components in the programmed sequence on one continuous taped reel. After sequencing, the taped reel of sequenced components is used to feed the Model 6288D component inserter.

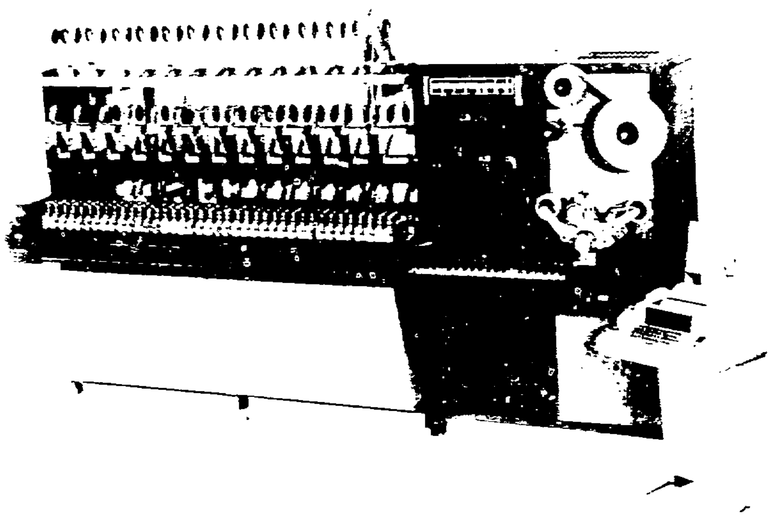
The component sequencer is controlled by a PDP-11/05 stored program controller with 8K memory, giving the system the capability needed to control 20 to 95 stations. The controller is pre-programmed for executive and administrative functions, simplifying work or pattern programs. Systems documentation gives program formats that are easy to follow and simple to execute. Communications with



Computer-Controlled Insertion System



DIP Sequencer/Inserter



30-Station Axial-Leaded Component Sequencer

Figure 25. Typical automated component insertion equipment

the controller are entered through a teletypwriter via ASCII code punched tape and the teletypwriter keyboard.

The component sequencer's dispenser heads, with linear feed, are designed to accept a wide range of axial-leaded components. Linear feed enables components to feed straight through the dispenser heads, engaging several component leads at one time and providing positive handling of components, thus ensuring quality and consistency in the sequencing operation.

The component sequencer is equipped with a heavy-duty conveyor chain. The chain-link design minimizes the possibility of misplaced or missing components by ensuring positive feed from the dispenser heads to the conveyor chain. Should a failure occur, the component sequencer immediately halts operation and the station number associated with the failed component is displayed on a digital readout, enabling the operator to correct the error and resume production.

A component centering device centers components as they feed into the retaping unit. The format unit can be adjusted to give the proper taping width needed for all standard component insertion requirements. A constant tension reeling system ensures uniform packing with less stress on the component leads.

A tape feed roll system enhances machine up-time because it gives over 10,000 feet of continuous tape for retaping components, or approximately 44 hours of operating time between reel changes.

4.2.2 <u>Machines AS3 and AS4 - Axial-Leaded Component Inserters, Printed Wiring Boards 1 and 2</u> -- The Universal Instruments model 6298D axial-leaded component inserter automatically inserts axial-leaded components into printed wiring boards.

The component inserter's dual head variable center distance (VCD) insertion system is controlled by a PDP-11/05 stored program controller with expandable magnetic core memory for additional program storage. The control system allows for fast and easy program changes, eliminating unnecessary system downtime.

Communications with the controller are entered through a teletypwriter via ASCII code punched tape and the teletypwriter keyboard.

Precise, high-speed X-Y table positioning is achieved by DC motors with closed loop feedback, with a table positioning accuracy of ±0.002 inch and a table movement of 900 inches per minute. An insertion area of 18 inches x 18 inches under each head accommodates the range of various printed wiring board sizes.

The component inserter's VCD insertion heads offer 1001 center distance selections, programmable in 0.001-inch increments. Head span ranges from 0.300 inch minimum to 1.300 inches maximum. With the programmable eight-position depth stop, the machine can insert axial-leaded components from jumper wires to large resistors and capacitors having up to 0.375-inch body diameters.

To improve quality and reduce board rework, a continuity check is used to sense the absence or presence of a component contrary to the program. Should a fault occur, the system automatically halts operation.

The cut and clinch units follow the same center distance and span range specifications as the insertion heads. The clinch on each unit may be adjusted to give any desired clinch angle from 45 degrees to 90 degrees with repeatability of ±0.005 inch or less depending on lead material.

4.2.3 Machine AS5 - Transistor Inserter, Printed Wiring Board 1 -- The transistor inserter automatically inserts TO-18 transistors into printed wiring boards. Its control and the X-Y positioning table are similar to the Universal Instruments model 6288D axial-leaded component inserter, previously discussed.

4.2.4 Machine AS6 - Dual In-Line Package (DIP) Integrated Circuit Sequencer/Inserter, Printed Wiring Board 2 -- The DIP integrated circuit sequencer/inserter installs DIP integrated circuits in sequence into printed wiring boards.

The Universal Instruments model 6785 DIP integrated circuit sequencer/inserter is controlled by a PDP-11/05 stored program controller with 8K memory. Communications with the controller are through a teletypwriter via ASCII code punched tape and the teletypwriter keyboard.

The DIP integrated circuit sequencer/inserter has many features incorporated into its control system to increase machine operating time. The multi-pattern program feature allows the controller to store many pattern programs simultaneously, thus eliminating repeated program loading operations. The on-line editing feature allows new pattern programs to be generated or existing programs to be edited while the machine is operating.

The omit/fill-in feature enables the operator to provide the controller with information to omit an empty stick magazine should the inventory of a particular DIP run out. Once the inventory is replenished, one simply starts using the omitted magazine with a fill-in command.

The control system provides vital management information when required. Such information includes the number of components inserted, the quantity of completed printed wiring boards, and X-Y coordinate printouts.

The DIP integrated circuit sequencer/inserter accepts many manufacturers' stick magazines for DIP input. It can insert 6-, 8-, 14-, 16-, and 18-lead DIPs intermixed, including most side leaded, brazed DIPs as well as ceramic DIPs with glass seals. Intermixing of units means random selection. Sequenced, inserted DIPs with leads cut and clinched are thus provided to meet specific requirements.

For stick magazine load and unload operations, the machine has a 12-stick ready-pac which provides a way for the operator to resupply the machine with 12 new stick magazines at one time, without interrupting machine operation. The ready-pac has a reservoir of its own, enabling the operator to visually check DIP input levels, thus providing more time to resupply the machine.

The twin ready-pac reservoir plus the input (machine) reservoir allows for as many as 400 eight-leaded DIPs to be loaded at one time. Combined with the 24-stick magazines, the DIP integrated circuit sequencer/inserter gives the capacity needed for continuous operation.

Positive handling of DIPs from selection, to preforming of leads, to the pressure-sensitive insertion head which delicately inserts the DIP ensures better quality and greater reliability in DIP insertion. Should a DIP insertion be missed, the machine can remedy the failure with its automatic repair function. The operator presses the repair button, causing the controller to store, in memory, the X-Y coordinate and magazine number associated with the omitted DIP. Then, at the completion of the operations on the printed wiring board, the operator presses the start button, automatically selecting and inserting the missed DIP.

The DIP integrated circuit sequencer/inserter can be equipped with either an inward or outward cut and clinch unit. The inward cut and clinch units are available as quick change tooling so that all leads or any combination of leads can be cut and clinched to meet insertion requirements. The outward cut and clinch unit requires all leads to be cut, then formed outward. Precise X-Y table positioning is achieved by DC motors with a closed-loop feedback, resulting in accurate high-speed positioning. The table size is 18 inches x 18 inches.

4.3 Wave Soldering Machine

The soldering of printed wiring boards will be accomplished on a wave soldering machine developed by Electrovert Inc. and identified as model 517-PCI. This machine has a conveyor which is inclinable up to 8 degrees to facilitate soldering on a horizontal plane or to incline the conveyor and take advantage of the lambda wave configuration.

A major feature of this machine is the foam fluxer to initially coat the printed wiring board in order to provide the necessary cleaning action. A combination flux dryer and panel preheater are included to provide a controlled temperature which will evaporate the flux solvent at a rate to allow adequate time for the flux agents to remove oxides. The preheating procedure thermally preconditions the printed wiring board to prevent distortion and provides adequate heat to overcome the heat sinking effect of components and metals on the printed wiring boards. The soldering lambda wave is guided to shape and controls solder flow. This wave is smooth and planar with a slightly inclined surface and provides a washing action on the bottom side of the printed wiring boards. It assists in promoting wetting, depositing a minimum amount of solder, and eliminating bridging. The printed wiring boards are cleaned in a model LSC-BR wave cleaner while they are submerged to simultaneously clean the top and bottom. The underside of the printed wiring boards are then scrubbed by variable-speed rotating brushes.

4.4 Printed Wiring Board Punch Out Station

This is a manual station required to separate the nine individual printed wiring boards from the carrier array used in the automated component insertion and wave soldering operations. See figure 26.

Because of the difference in size and shape of the components attached to each printed wiring board (1 and 2), two different punch out stations will be required.

Each station will consist of a Danly two-post air-actuated press having a 1-ton capacity, 3-inch stroke, and 5-1/2-inch open height mounted on a Danly model 1010 die set with a type A control circuit (single-stroke, two-hand non-tiedown).

Each station will require custom-designed tooling for separating the nine printed wiring boards in the array in order to provide special clearances for the assembled components.

The air presses will be capable of 90 continuous strokes per minute.

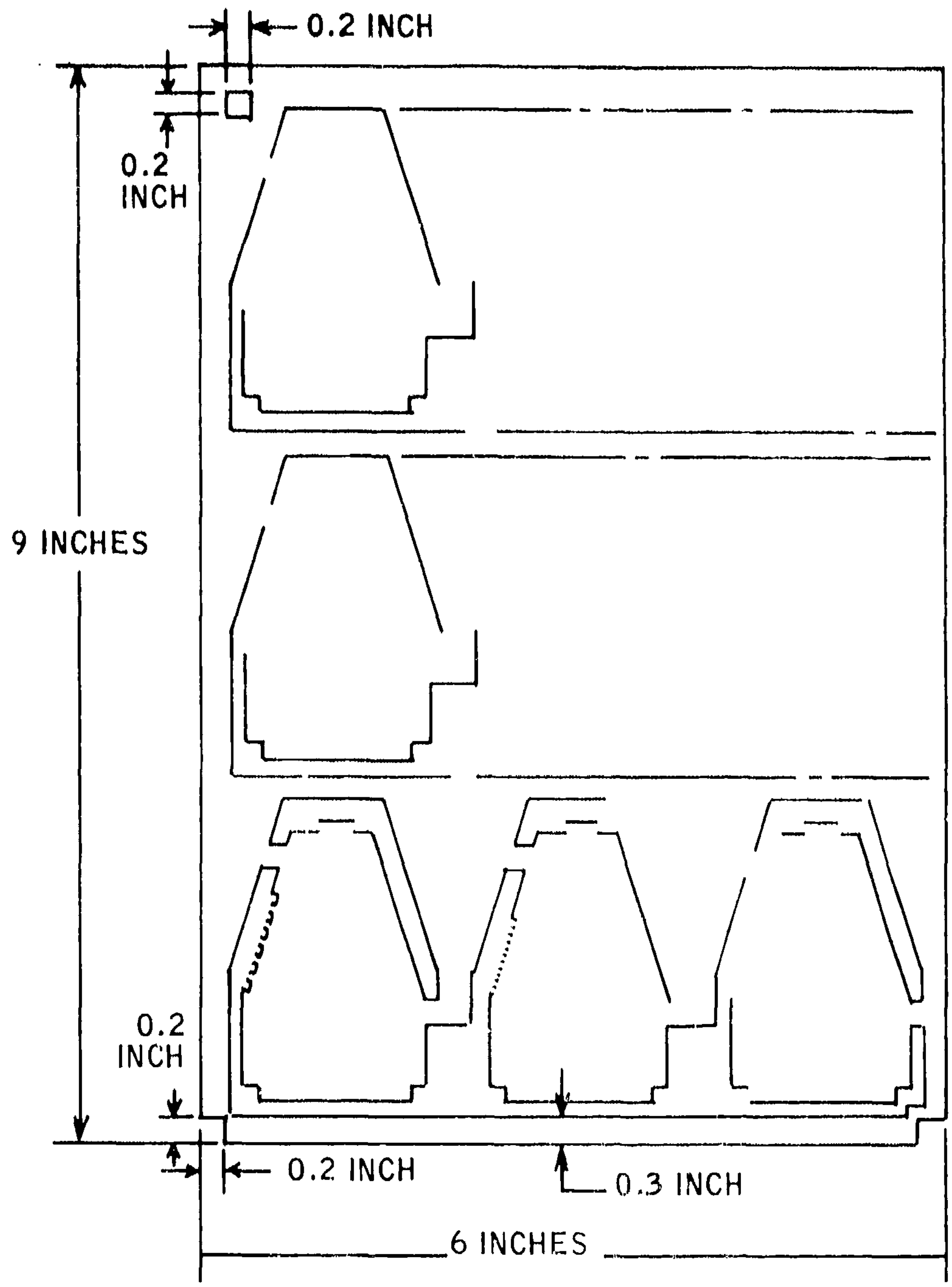


Figure 26. Printed wiring board carrier

4.5 Manual Assembly Operations

The required manual operations for the fuze automated assembly line are accomplished at four bench stations. The operations performed at each of these bench stations are described in the following paragraphs (reference figures 20 and 21).

4.5.1 Bench 1 -- This is a manual station that accomplished manual insertion of three components on printed wiring board 1.

The components assembled at this bench station are listed below:

Item	Part Number
Precision oscillator	11711427
Impact switch	11718418
Encapsulated transformer	11711448

The next operation is the wave solder machine.

4.5.2 Bench 2 -- This is a manual station that accomplishes the manual insertion of one component, the interface circuit, on printed wiring board 2.

The component inserted at this bench station is the interface circuit (part number 10990455).

The next operation is the wave solder machine.

4.5.3 Bench 3 -- This is a manual station that accomplishes the mating of the printed wiring board 1 assembly and the printed wiring board 2 assembly. The electronic cover and orientation cup assembly and the setting ring and nose plug assembly are also added at this bench station to complete the electronics subassembly.

This is an assembly and solder station and requires special handling for the two monolithic integrated circuits because they can be damaged by static electricity.

The parts assembled at this bench station are listed below.

Item	Part Number
Printed wiring board 1 assembly	11711413
Printed wiring board 2 assembly	11711414
Electronic cover and orientation cup assembly	From machine E1
Setting ring and nose plug assembly	11711450
Lead frame strip	11711419

The next operation is the pre-encapsulation electrical test.

4.5.4 Bench 4 -- This is a manual assembly station that brings the rear fitting assembly and electronics subassembly together in proper orientation just prior to the hydraulic crimping operation.

A greased O-ring is installed in the groove on the nose cone outside diameter. An operator can visually index the notch in the E-head cup with the matching spring pin on the rear fitting sleeve. This will ensure minimum time to locate the battery terminals in their respective coil contact.

Parts assembled at this bench station are listed below:

Item	Part Number
Rear fitting assembly	11720291
Electronics subassembly	11711430
O-ring	MS9386-033
Washers (3)	11711444

The next operation is machine F5.

4.6 Individual Automated Assembly Machine Descriptions

4.6.1 Machine E1 - Electronic Cover and Orientation Cup Assembly--

4.6.1.1 Operations -- Machine E1 assembles the three contact coils, two pad contacts, and the orientation cup to the electronic cover. The electronic cover is heat staked and probed for height in the orientation cup. The five contact leads are cut off to length and bent to

retain in position. All parts are probed for presence and position. See Figure 27.

4.6.1.2 Parts Assembled --

Item	Part Number
Electronic cover	11711409
Contact coils (3)	11711418
Pad contacts (2)	11711417-2
Orientation cup	11711410

4.6.1.3 Lot Sample Inspection -- A lot sample inspection is planned to check the positional location of the cup to the cover and the heat stake pushout force as shown in drawing 11711428.

4.6.1.4 Next Operation -- Bench 3.

4.6.2 Machine E2 - Setting Ring and Nose Plug Assembly (11711425)--

4.6.2.1 Operations -- Machine E2 assembles and heat stakes the two setting ring assemblies and the contact pad to the electronics nose plug. After probing the stake height (0.613 - 0.005 inch), the three leads are cut off to length and bent 90 degrees. All parts are probed for presence and position. See figure 28.

4.6.2.2 Parts Assembled --

Item	Part Number
Electronics nose plug	11711407
Setting ring assembly	11711450-1
Setting ring assembly	11711450-2
Contact pad	11711417-1

4.6.2.3 Lot Sample Inspection -- A lot sample inspection is planned to check the following items:

- The true position of the setting rings (drawing 11711425).
- The maximum diameter at the setting ring to the electronics

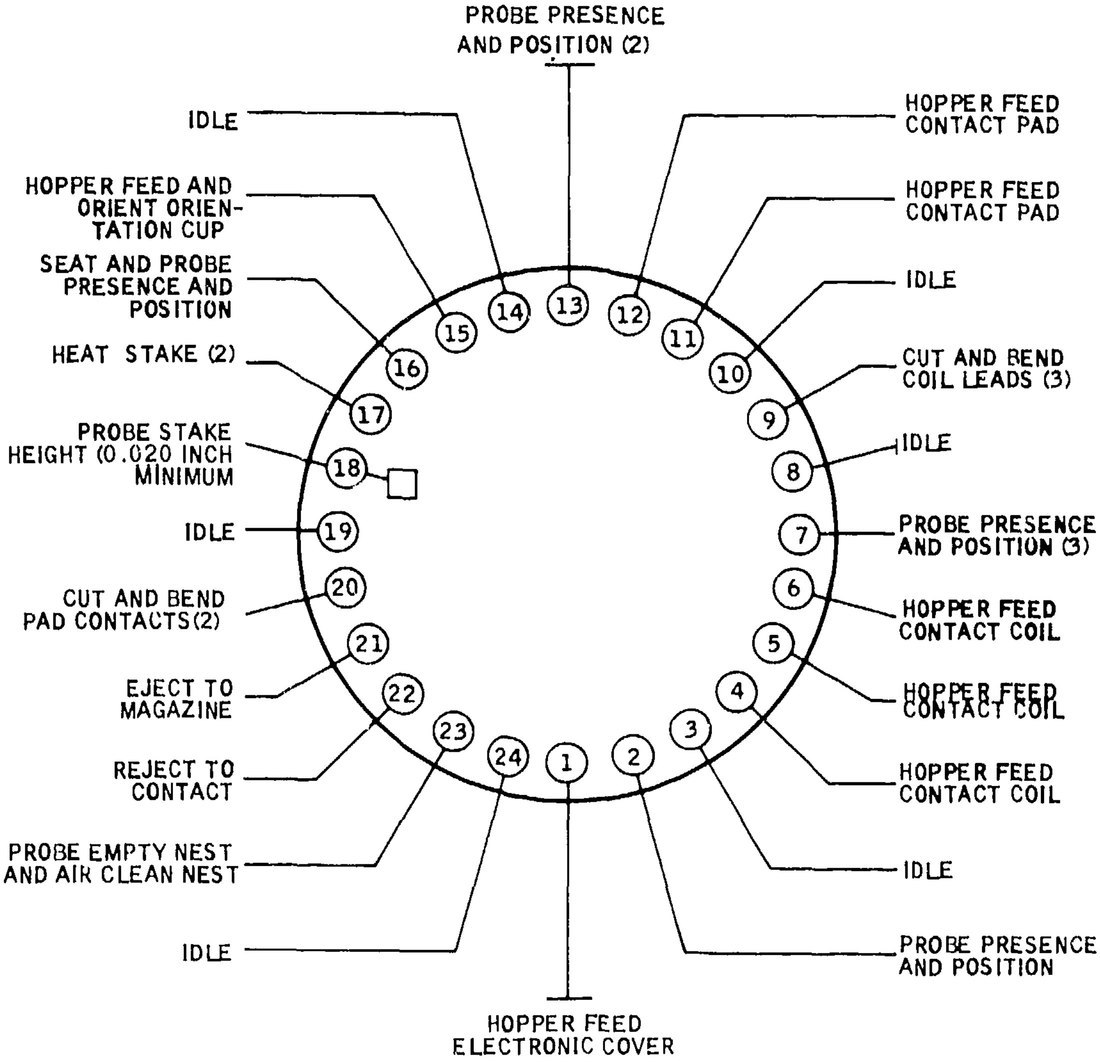


Figure 27. Dial schematic, machine E1 - electronic cover and orientation cup assembly

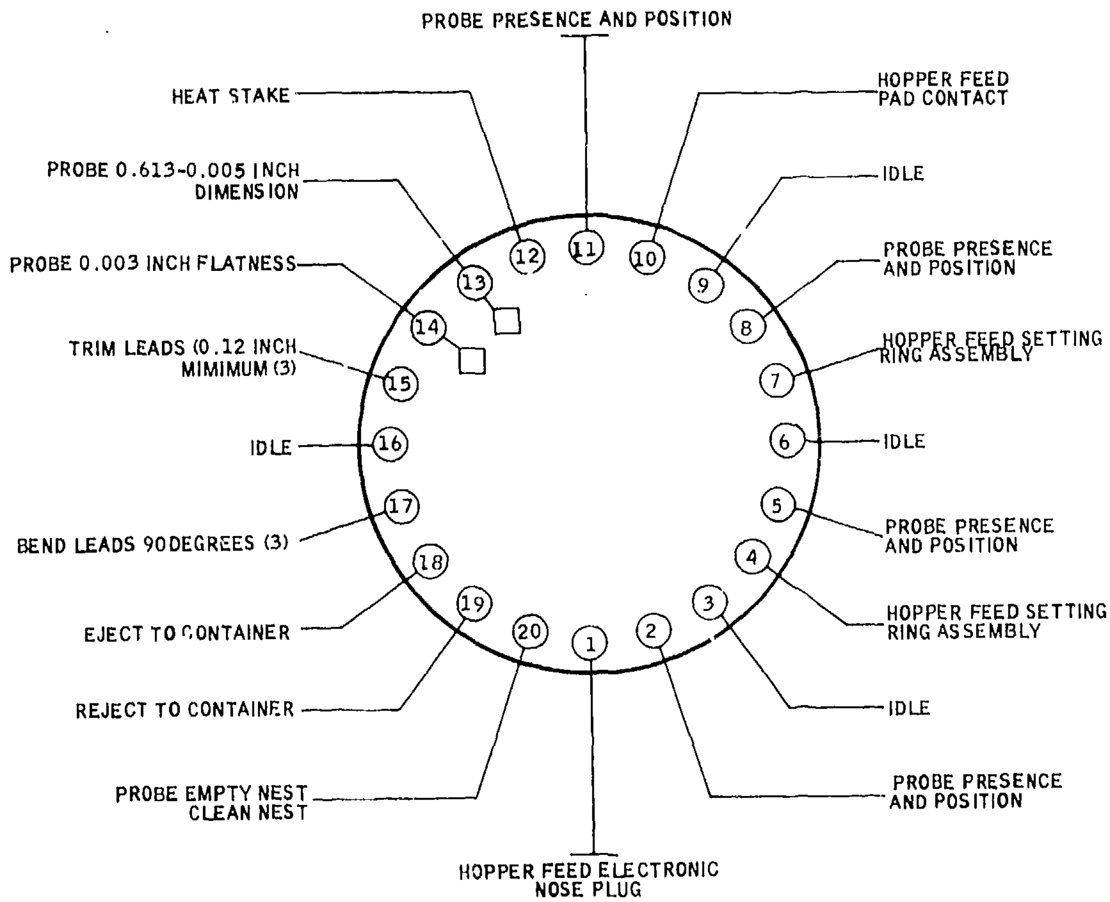


Figure 28. Dial schematic, machine E2, setting ring and nose

nose plug (drawing 11711425).

- Electrical continuity (drawing 11711425).

4.6.2.4 Next Operation -- Bench 3.

4.6.3 Machine E3 - Electronics and Nose Cone Assembly (11711430)--

4.6.3.1 Operations -- Machine E3 greases and assembles an O-ring to the nose plug of the electronics subassembly. The electronics subassembly is then inserted in the nose cone and staked. Because of the nature of this machine, the probes will stop the machine for operator correction. All parts will be ejected to a stub track for further disposal. See figure 29.

4.6.3.2 Parts Assembled --

Item	Part Number
Electronics subassembly	11711428
O-ring grease	11711276
O-ring	MS9386-015
Nose cone	11711408

4.6.3.3 Lot Sample Inspection -- None.

4.6.3.4 Next Operation -- Encapsulation of E-head.

4.6.4 Machine E4 - Nose Cone (11711430) Trimming --

4.6.4.1 Operations -- Machine E4 machines and vacuum removes the waste of the fill tube and the two vent tubes. The tubes will be checked for proper height after machining.

The life expectancy of the carbide cutters is approximately 1000 parts. Depending on the cutting time required, this machine should run at 15-20 cycles per minute, producing approximately 30 assemblies per minute from this double-tooled table. See figure 30.

4.6.4.2 Parts Assembled -- None.

4.6.4.3 Lot Sample Inspection -- A lot sample inspection is planned to check the dimensional tolerance of the nose plug assembly to the nose cone and the dimensional tolerance of the orientation cup to

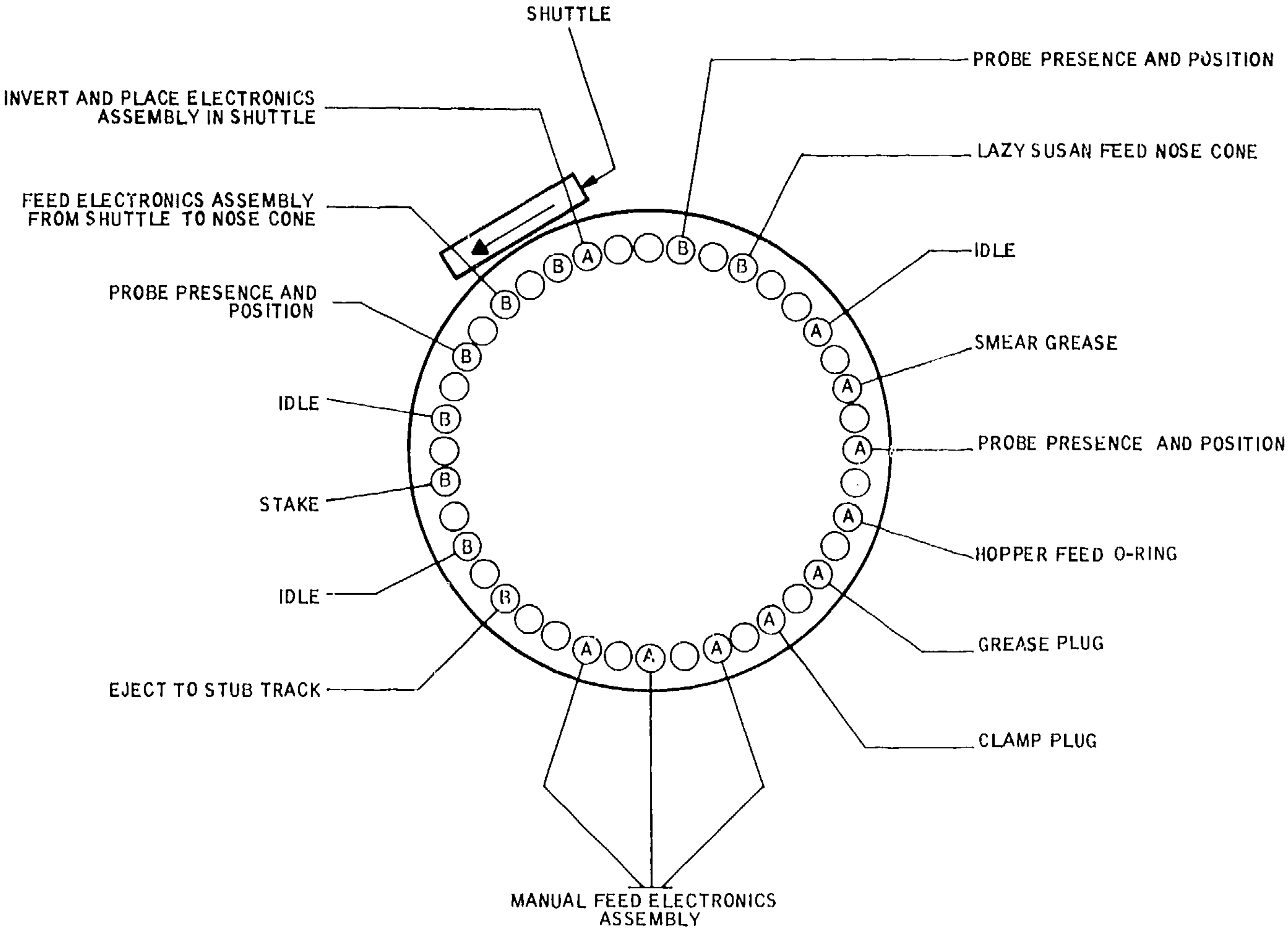


Figure 29. Dial schematic, machine E3 - electronics and nose cone assembly

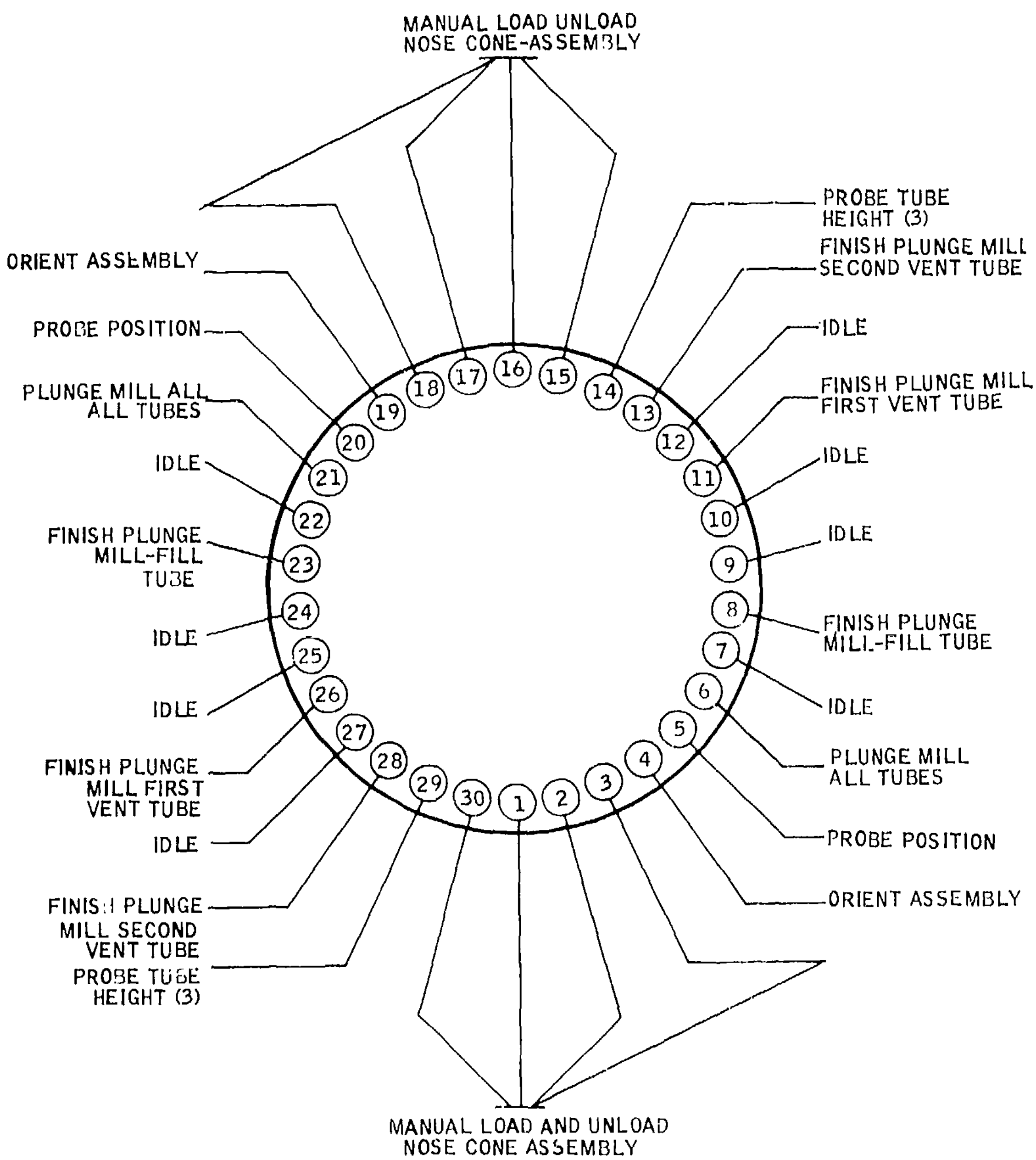


Figure 30. Dial schematic, machine E4 - nose cone trim machine

the nose cone. In addition, the machining of the excess epoxy, fill, and riser tubes will be checked. See drawing 11711430.

4.6.4.4 Next Operation -- Machine T2 - Post-Encapsulation Electrical Test.

4.6.5 Machine F1 - Detonator Block Assembly (11722620) Operation 1 --

4.6.5.1 Operations -- Machine F1 inserts and stakes the flat washer and the ground pin clip into the detonator block. All parts are probed for presence and position. See figure 31.

4.6.5.2 Parts Assembled --

Item	Part Number
Detonator block	11720298
Ground pin clip	11720214
Flat washer	MS27183-4

4.6.5.3 Lot Sample Inspection -- None.

4.6.5.4 Next Operation -- Machine F2 - Detonator Block Assembly Operation 2.

4.6.6 Machine F2 - Detonator Block Assembly (11722620) Operation 2 --

4.6.6.1 Operations -- Machine F2 assembles the detonator clip, detonator, contact detonator insulator, and the detonator contact to the detonator block subassembly. After a 2.0- to 10.0-ohm resistance check is made, the power supply with a shorting clip is then assembled to the detonator block subassembly. All parts are probed for presence and position. See figure 32.

4.6.6.2 Parts Assembled --

Item	Part Number
Detonator block subassembly	11722620 (from operation 1)
Detonator clip	11728234
Detonator	11722405

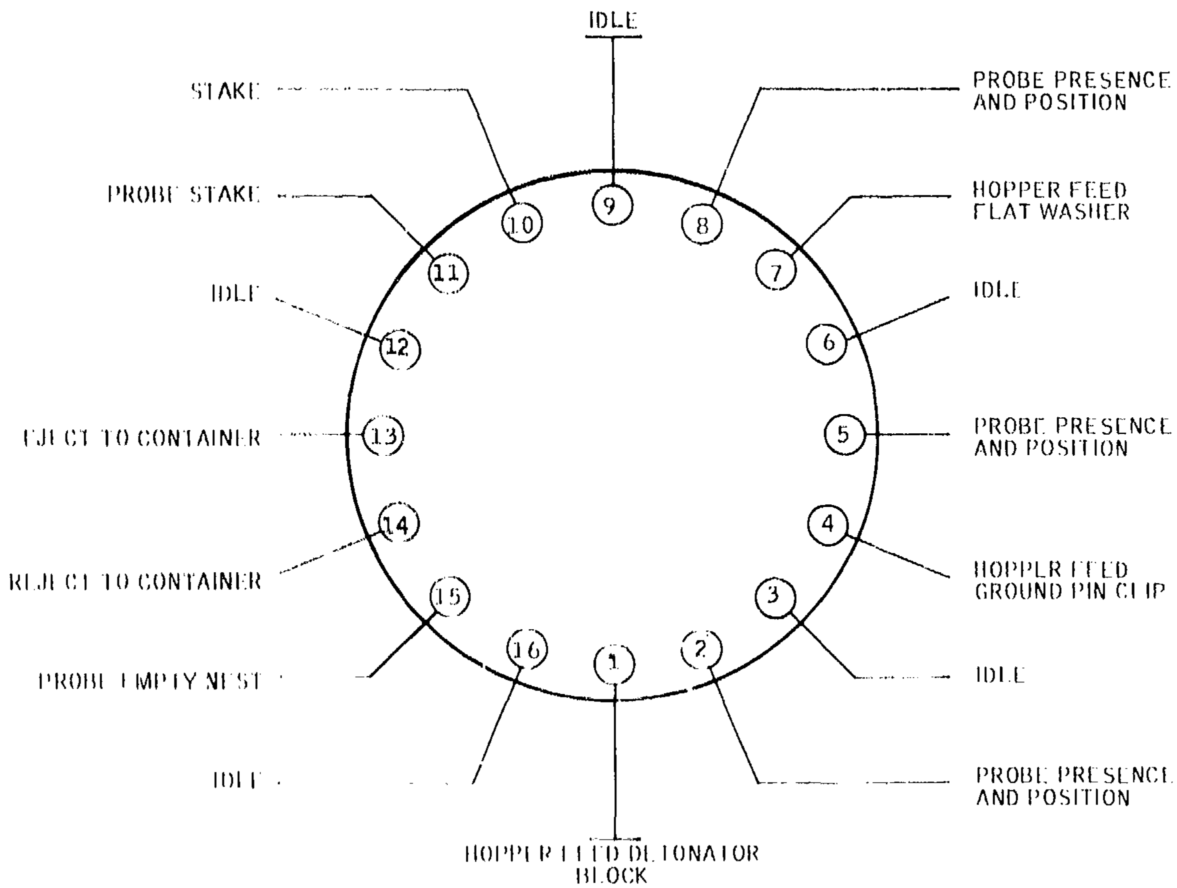


Figure 31. Dial schematic, machine F1 - detonator block assembly operation 1

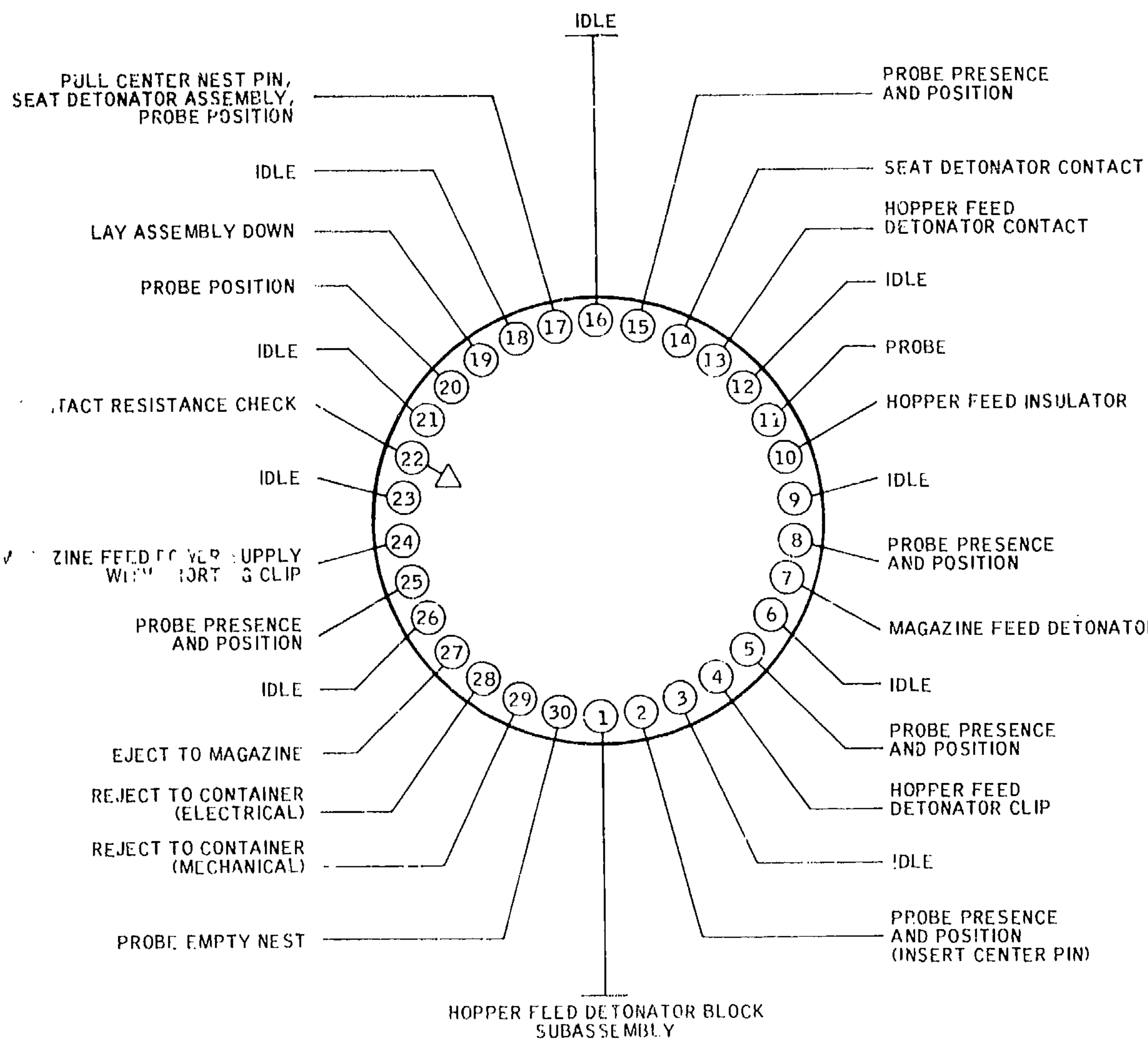


Figure 32. Dial schematic, machine F2 - detonator block assembly operation 2

Contact detonator insulator	11720299
Detonator contact	11720297
Power supply with shorting clip	11720216 (shorting clip - 28107993)

4.6.6.3 Lot Sample Inspection -- A lot sample test is planned for power supply electrical requirements as defined in drawing 11720216.

4.6.6.4 Next Operation -- Machine F4 - Rear Fitting Assembly Operation 2.

4.6.7 Machine F3 - Rear Fitting Assembly (11720291) Operation 1 --

4.6.7.1 Operations -- Machine F3 applies RTV and assembles the lead assembly and the spring pin to the sleeve. The lead assembly is probed for presence and position, blue side up, and then staked. The spring pin is pressed in position and probed for the 1.644-0.010-inch dimension. See figure 33.

4.6.7.2 Parts Assembled --

Item	Part Number
Sleeve	11722622
RTV	Type 1, MIL A-461
Output lead assembly	11720258
Pin spring	MS51923-138

4.6.7.3 Lot Sample Inspection -- A lot sample inspection is planned to verify the lead cup stake integrity.

4.6.7.4 Next Operation -- Machine F4 - Rear Fitting Assembly Operation 2.

4.6.8 Machine F4 - Rear Fitting Assembly (11720291) Operation 2 --

4.6.8.1 Operations -- Machine F4 checks the S&A module for the safe condition and places it in the rear fitting subassembly. The bias spring is then blanked from a strip, coming directly from a punch press, and placed in the rear fitting subassembly. The detonator

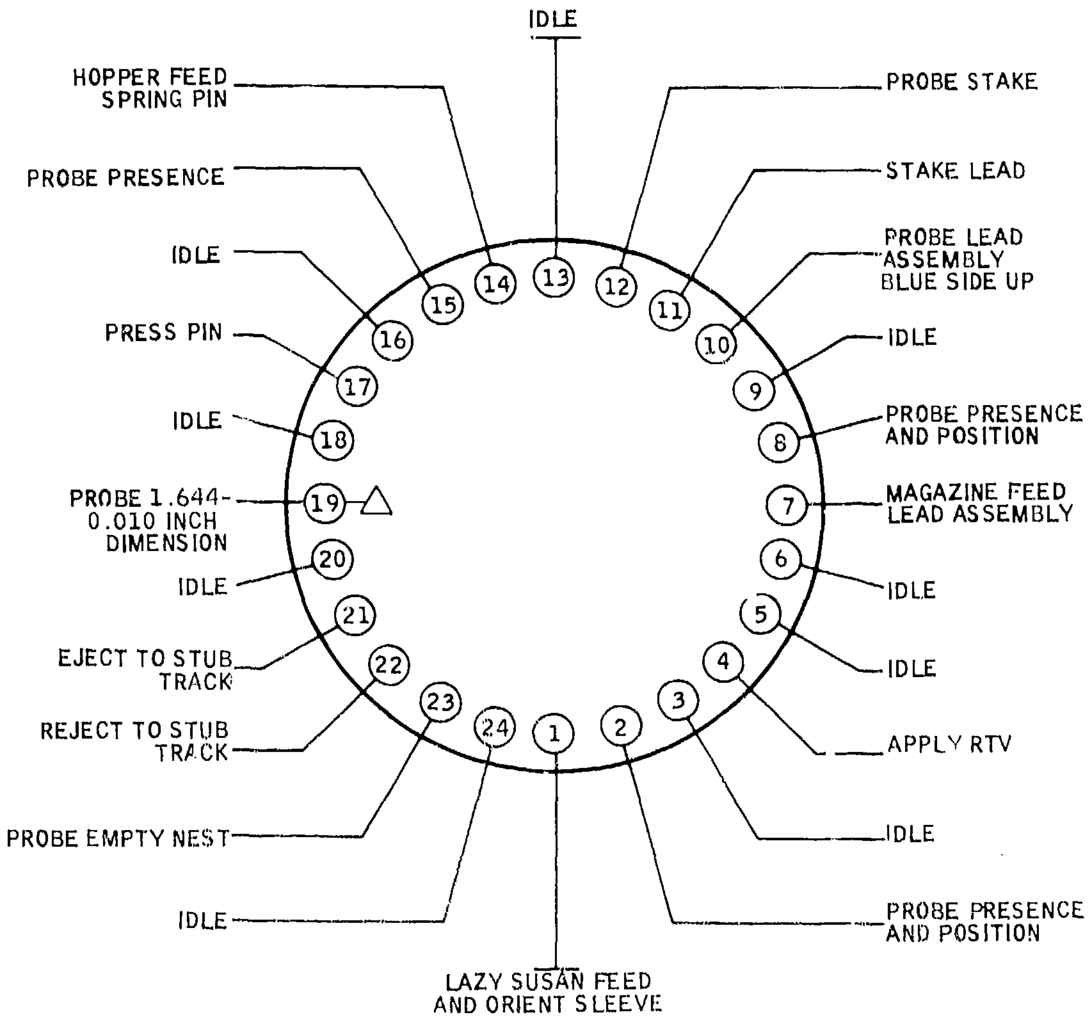


Figure 33. Dial schematic, machine F3 - rear fitting assembly operation 1

block and power supply assemblies are then fed, probed for position, staked, final checked, and then ink stamped. See figure 34.

4.6.8.2 Parts Assembled --

Item	Part Number
Rear fitting subassembly	11720291 (from Operation 1)
S&A module	11720300
Bias spring	11720296
Detonator block and power supply assembly	11722620 and 11720216

4.6.8.3 Lot Sample Inspection -- A lot sample inspection is planned after this operation as required by the appropriate classification of defects and tests listed in the drawing 11720291.

4.6.8.4 Next Operation -- Final assembly machine.

4.7 Automated Encapsulation System

This system provides for the automated potting of the fuze electronics assembly. The potting material is a silicon-filled epoxy consisting of a base mixture and a hardener, mixed in a specific ratio. The system provides for evacuating the material and filling the assembly with the mixed potting material.

The flow diagram of the automated encapsulation system is shown in figure 35. The encapsulation system consists of the following elements:

- Mixing system.
- Transfer system.
- Resin system (reservoir with agitator).
- Hardener system (reservoir with agitator).
- Metering system with mix head.
- Vacuum system.
- Heating system.

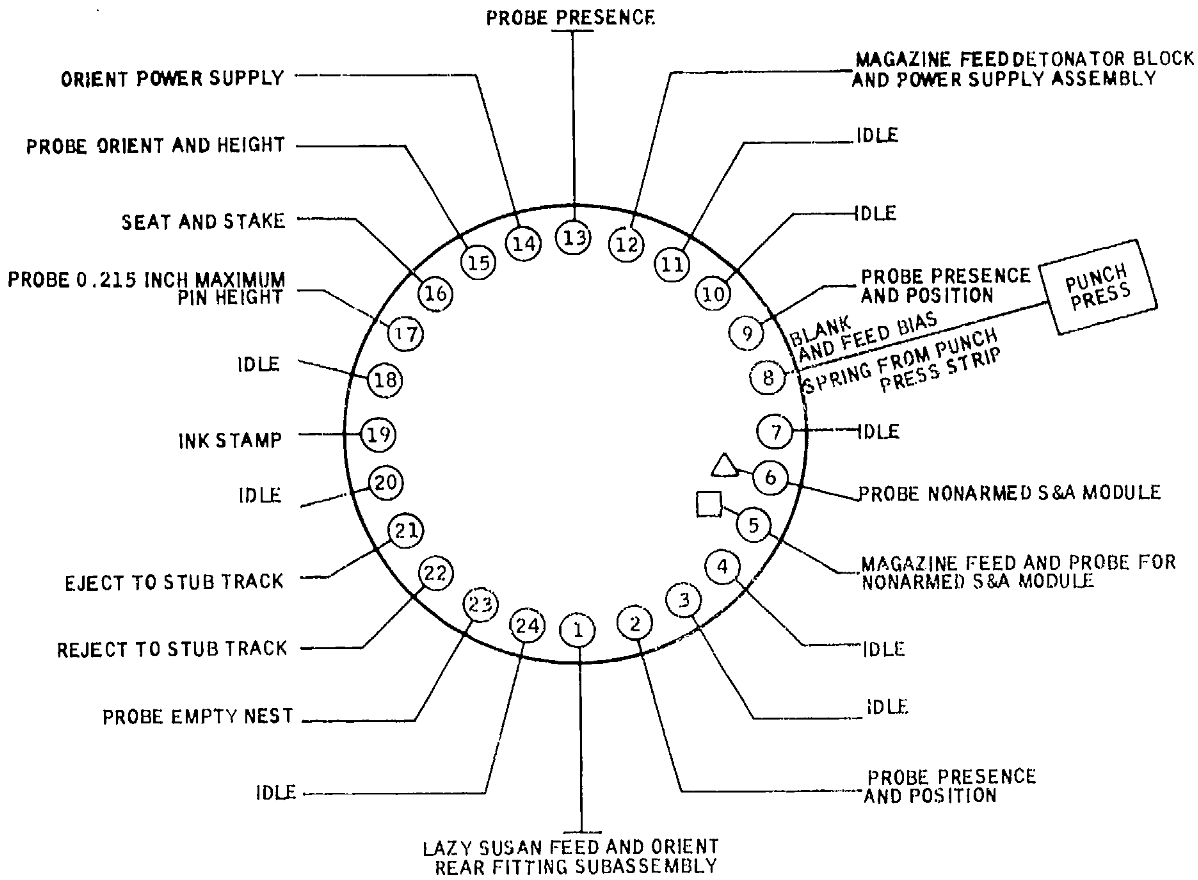


Figure 34. Dial schematic, machine F4 - rear fitting assembly operation 2

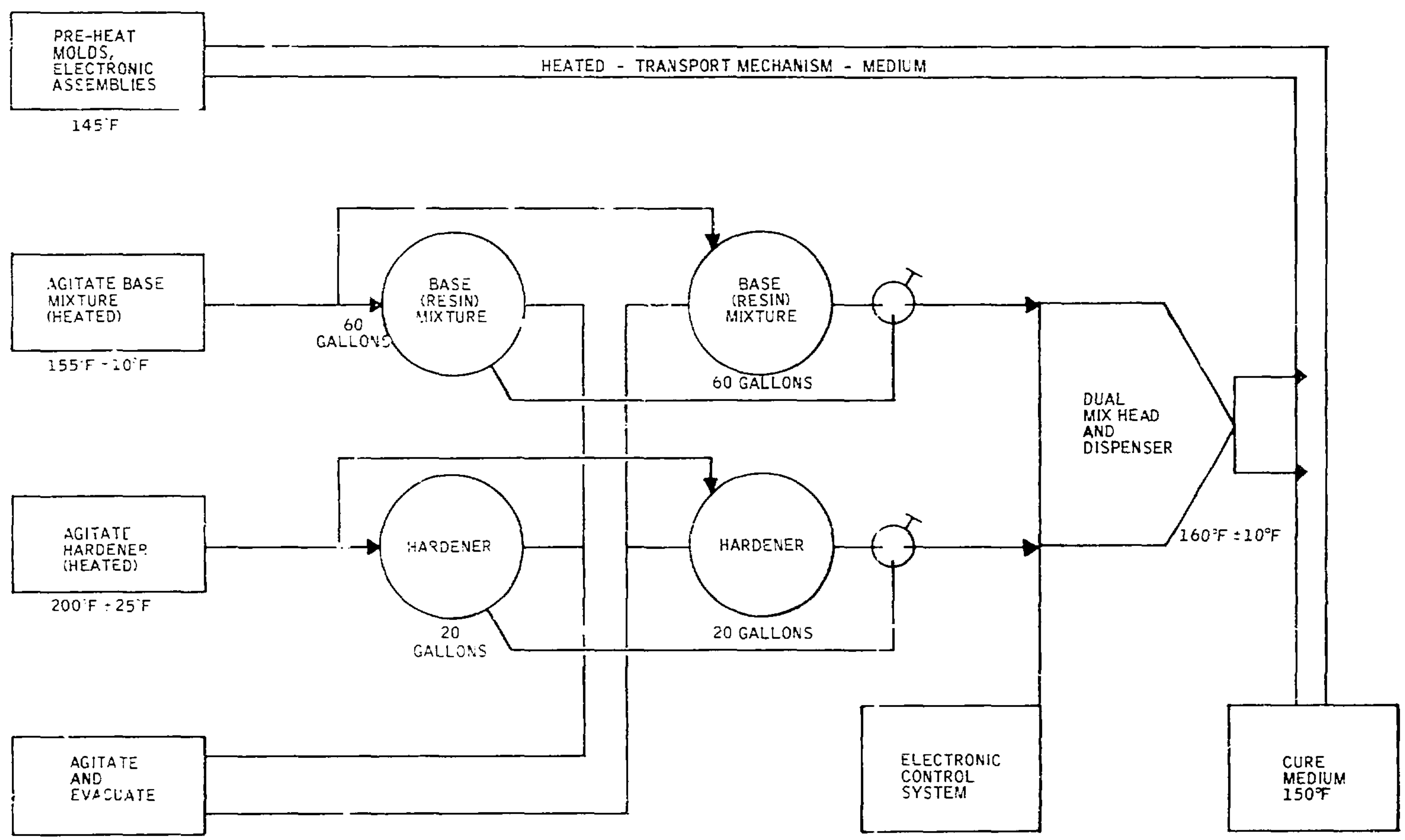


Figure 35. Automated encapsulation system flow diagram

- Electronic control system.

The base potting material is received in containers (tanks) ranging in size from 5 to 60 gallons. Prior to use, the base potting material is mixed by means of an agitator to ensure a homogeneous mixture and transported to a holding reservoir by means of the transfer system. Two holding reservoirs are provided for each component of the potting material (base potting material and hardener) in order to ensure that the encapsulation operation will not be shut down by a filling or cleaning operation on the reservoirs. The reservoirs are evacuated and the agitators activated in order to remove all air from the base potting material and hardener prior to final mixing and injection into the fuze electronics assembly.

The base potting material and hardener are combined and mixed in a dual mix head and dispenser controlled by the electronic control system.

The fuze electronic assemblies are preheated prior to encapsulation. After preheating, the assemblies are moved to the dispenser by the transfer system and filled with the epoxy mixture. After filling, the assemblies are then moved to the cure area.

Each fuze electronic assembly requires 0.25 pound of material. Based on a production rate of 100,000 units per month on a 1-8-5 production basis and allowing for normal efficiency reduction, the processing time for the encapsulation of each assembly is 4.5 seconds. The above schedule results in an epoxy consumption rate of 80 gallons per shift.

Based on the above conditions, the characteristics of each of the elements of the encapsulation system are described in the following paragraphs.

4.7.1 Mixing System -- This system will accomplish the agitation and mixing of the base potting mixture (resin) to ensure definite volume consistency of the mixture prior to transferring it to tanks for use.

It comprises a set of industrial shakers or mixers fitted with temperature-controlled containers and accomplished a heating of the base potting mixture as it is mixed.

At this time, the container size will be 1 gallon, and, therefore, it appears feasible to envision an automated transfer mechanism system for transferring the mixed and heated contents of these gallon can tanks to a larger 60-gallon tank.

4.7.2 Transfer System -- The function of this system is to transfer agitated and heated containers of the potting compound to a larger container. This system is expected to handle about 24 such containers per shift. Handling is interpreted to mean to open and empty containers into larger containers.

This system can be either manual or automatic. The present preference is for a mix of both manual and automatic operations where the agitation and heating are done automatically and an operator handles the loading, unloading, opening, and pouring of potting compound.

4.7.3 Resin System -- This system is a pressurized heated tank complete with agitator and is connected to the metering head by a heated hose.

The system can accommodate two 60-gallon tanks. One tank is used for holding and preparing one batch while the other is in use.

The system will be equipped with a pressure indicator, pressure regulators, a preset safety valve, and a viewing port, in addition to the heater and agitator mentioned above. Also, sensors for monitoring all temperatures and liquid levels are included.

Evacuation of the base potting material is accomplished in the tanks by means of a vacuum cycle, after which the tank is pressurized. The material moves via air pressure through heated hoses to the metering system.

4.7.4 Hardener System -- This system is essentially a pressurized tank filled with heated hardener and connected to the metering system by a heated hose.

Some evacuation of air bubbles is done on the hardener in the tanks before the tanks are pressurized.

4.7.5 Catalyst System -- If the need arises for an accelerated cure catalyst, this system will provide that function. The configuration will be dependent on the type of catalyst and the unique requirements for handling and dispensing/metering the catalyst.

4.7.6 Metering System with Mix Head -- This system contains mechanical devices that measure specific amounts of the base potting material and specific amounts of hardener. An optional catalyst may also be metered. The mix head then blends these components and the mixed potting compound is pumped into the heated E-head molds.

The exact amount of the above components pumped is accomplished by two air-driven oil pumps using different gear ratios. The pumps use a bladder head for higher effectiveness and lower maintenance.

The overall metering system, with its mix head, is monitored and controlled by the electronic control system.

4.7.7 Vacuum System -- This system will perform all evacuation functions. It will remove all air bubbles from the base potting material tanks and the hardener tank. It will also evacuate the E-head molds if required.

It will consist of a vacuum pump connected to the hardener tank and the base potting material tanks by hoses. This pump will provide a vacuum as low as 4 millimeters of mercury in a 227-liter volume within 15 minutes.

4.7.8 Heating System -- This system will provide the tank and hose heating function as required. It will also provide heat to the molds and will be controlled by the electronic control system.

A forced air heating system is recommended since this system has the least chance of destroying units should the automated assembly line be stopped. Also, such a system will be easily maintained. Heating coils are recommended for heating the hoses.

4.7.9 Electronic Control System -- This is the "brain" of the dispensing equipment. It will use solid-state logic circuitry in modular form for easy access and maintenance. This system monitors, controls, and protects the dispensing equipment as follows:

- It senses and controls all the temperature zones of the dispensing equipment.
- It measures and controls the volume of potting compound poured into the mold.
- It controls the ratios of the base potting material and hardener as they are metered through the system.
- It senses when a mold is in position for pouring.
- It senses the absence of a mold.
- It automatically stops the potting compound from pouring if the automated assembly line is stopped for any reason.

- It senses the level of material in the tanks.
- It senses pressure changes in the tanks and the system.
- It monitors the performance of the active parts of the system; metering head, bladder pumps, valves, and lines for clogging.
- It controls audible and visual alarms and indicates problem areas and the nature of problems.

This system is a typical electronic control and monitoring system in that it is composed of a solid state memory, a control panel, and appropriate indicators.

4.7.10 Transport Mechanism -- This system will be composed of conveyors and simple operation stations. It will ensure that the molds are brought to the potting dispenser as efficiently as possible. It will be designed to allow heating of the entire conveyor leading up to the pouring of the potting compound. It will also convey potted units to the cure cycle.

4.8 Automated Test Equipment

The automated test equipment consists of three separate test machines. Two of these are functional test machines, one of which performs a pre-encapsulation test (machine T1) and the other a final functional test (post-encapsulation) (machine T2) of the electronics and nose cone assembly. The two functional test machines differ only in that the final functional test machine shall be capable of recording on magnetic tape, 100 percent variables data. The third automated test machine (machine T3) shall be for setting and interrogating the fuze. It shall also have the capability of recording, on magnetic tape, 100 percent go/no-go data.

4.8.1 Machines T1 and T2 - Functional Test Equipment (Pre- and Post-Encapsulation) -- This equipment shall accomplish the testing and inspection of electrical parameters of the electronics and nose cone assembly. The equipment shall be designed for a minimum net capability of 100,000 electrical tests per month on a 1-8-5 production basis, allowing for all expected equipment downtime for maintenance and repair. This will require eight test stations.

The electronics and nose cone assembly test equipment shall test the electronics and nose cone assembly in accordance with the test requirements specified in drawing 11711430. The equipment shall also be capable of testing the electronics assembly (drawing 11711428) in accordance with the test requirements specified in drawing 11711430.

Figure 36 is a component block diagram of the test equipment.

The test equipment shall incorporate operator initiated built-in automatic self-check tests which will isolate approximately 75 percent of all possible test equipment failures. Calibration failures are excluded from this requirement. Detected failures by the self-check test shall be identified per the functional block (figure 37) that requires repair.

The test equipment shall be controlled by software programming written in PLM and/or ATLAS languages.

4.8.1.1 - E-Head Test Set -- The following are the requirements for and the description of the automatic E-head test set. Figure 37 is a functional block diagram for the E-head test set which shall consist of the following major components:

- XM36E1 fuze setter.
- A programmable power supply for the E-head.
- Measurement and detection equipment.
- Computer/controller
- Operator status/control panel

The test set shall utilize an XM36E1 fuze setter which provides the major control for sequencing operations during the checking, setting, and verifying of E-head functions. The setter is an important component in the test equipment and by itself exercises about 80 percent of the E-head electronics. The setter shall be used to set and interrogate the E-head.

The programmable operational power supply shall provide step or ramp generation and shall provide the E-head with time-out function initiation. The master timer/counter of the test equipment shall also be initiated from this power supply.

Measurement and detection circuits shall provide the following specific functions:

- Detecting the levels which indicate the various events, such as first scaler going low, capacitor starting to charge, and detonator event.

- Recording the various event times.

- Measuring the energy applied to the simulated detonator load.

- Measuring the scaler period.

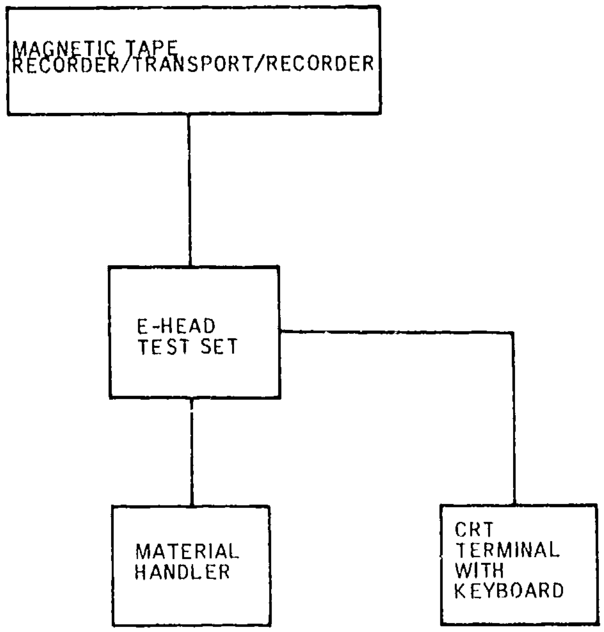


Figure 36. Component block diagram, automatic E-head test set

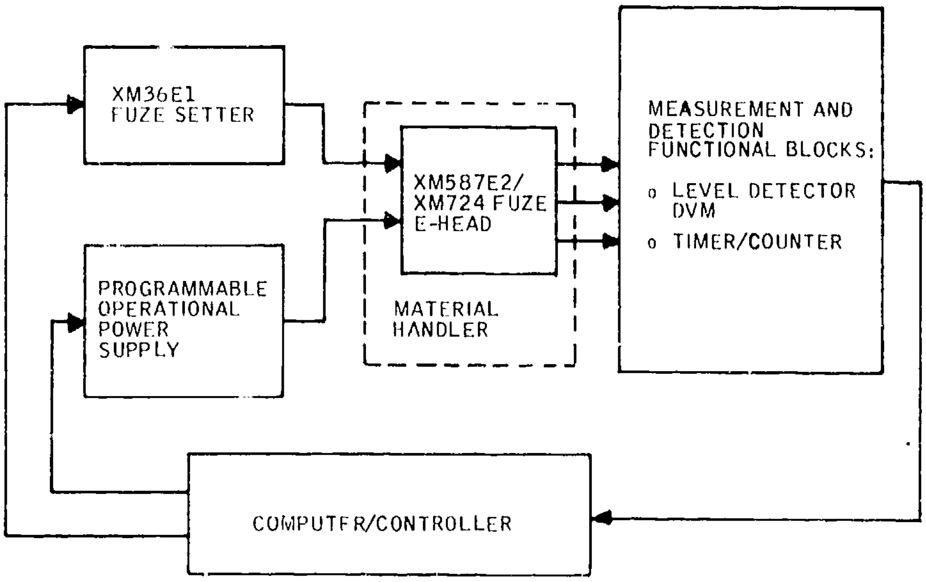


Figure 37. Functional block diagram, automatic E-head test set

* Measuring the average fuze current.

The computer/controller shall be programmed to automatically test an E-head and record the data results on 800-bit-per-inch, nine-track, 1/2-inch computer tape on 2400 feet standard reels and hubs. The program shall contain the software drivers or the various functional blocks, the high and low limits for each test, the test sequence, and utility features necessary to make the E-head test set functionally automatic and capable of testing the E-head in accordance with the requirements. The test program shall be stored in memory and shall be nonaccessible from the operator interface with the E-head test set.

Each E-head test set shall have an operator status/control panel which will contain the following features:

* E-head test set operating status (go/no-go).
* Operator-initiated test equipment self-check.
* Start/stop control of the tester.
* Go/no-go (pass/fail) indicator for each of 12 E-heads tested.
* An operator control switch to prevent/permit recording of test data.
* An end-of-test indicator which indicates all E-heads in the tray have been tested.

4.8.1.2 Material Handler -- The E-head shall be presented to the E-head test set via an automatic handler. An operator will load E-heads into circular 12-cavity trays and load the trays onto the handler. The units shall be tested in the trays. Failed units shall be ejected by the test equipment. The units which pass the testing shall remain in the trays for manual removal from the handler.

4.8.1.3 Magnetic Tape Recorder/Transport/Controller -- This shall provide a mass storage media for test data from the E-head test set and provide a means for program loading if needed by the test equipment design. The magnetic tape transport shall be 800-bit-per-minute 9-track tape and shall use standard hubs and reels with a minimum capacity of 2400 feet. ASCII code shall be standard.

4.8.1.4 CRT Terminal with Keyboard -- The cathode ray tube (CRT) terminal, complete with keyboard, shall provide operator-controlled displays of the test data and operator interface with the computer/controller as required by the test equipment design.

4.8.2 Machine T3 - Set and Interrogate Station -- This equipment will consist of the electronics from the functional test stations required for testing of the set and interrogate functions. The equipment would provide 100 percent go/no-go data to the data aquisition system.

The set and interrogate test station shall test the time set characteristics of the XM587E2/XM724 fuzes. The station shall set the fuzes and shall verify that the setting is within the limits as specified by the XM36E1 fuze setter. The fuze shall be set to point detonation and shall be interrogated to verify the proper point detonation setting. All fuzes, upon completion of the testing by this station, shall be set for point detonation operation in accordance with drawings 11711268, 11711433, and 11711435. The block diagram for the set and interrogate test station is shown in figure 38.

The test station shall incorporate operator initiated built-in automatic self-check tests which will isolate approximately 75 percent of all possible test equipment failures. Calibration failures are excluded from this requirement. Detected failures by the self-check test shall be identified per the functional block (figure 39) that requires repair.

4.8.2.1 Set and Interrogate Test Set -- The following are the requirements for and the description of the set and interrogate test set. Figure 39 is a functional block diagram for the test set.

The XM36E1 fuze setter shall be programmed for the desired function/load/time for the test. After completion of the test, the setter shall be interrogated for the results it normally would display.

The computer/controller shall be programmed to automatically set/interrogate a fuze via the XM36E1 fuze setter. The program shall contain the software drivers for the various functional blocks, the high and low limits for the set time, the test sequence, and utility features necessary to make the set and interrogate test station functionally automatic and capable of testing the fuze per the requirements. The test program shall be stored in memory and shall be nonaccessible from the operator interface with the tester.

Each test set shall have an operator status/control panel which will contain the following features:

- Tester operating status (go/no-go).
- Operator-initiated self check.
- Start/stop control of the tester.

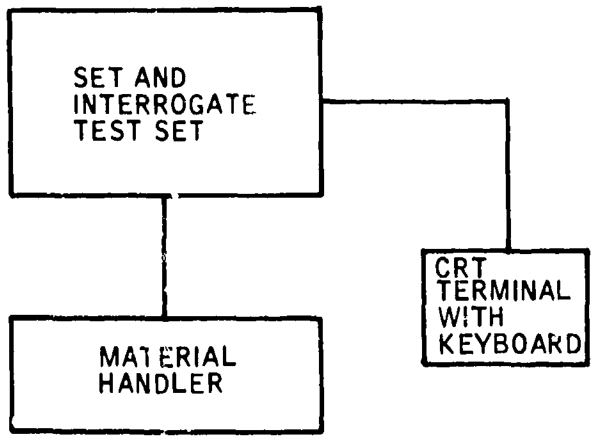


Figure 38. Component block diagram, set and interrogate test station

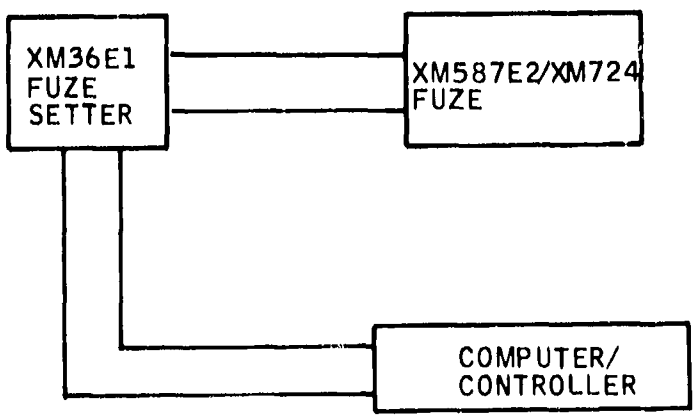


Figure 39. Functional block diagram, set and interrogate test station

- Go/no-go (pass-fail) indicator.

- An end-of-test indicator.

- Electrically advanced manual reset counters for number of fuzes tested and number of fuzes passed.

4.8.2.2 Material Handler -- The XM587E2 fuze, less booster pellet and cup, or the XM724 fuze, shall be presented to the test set via an automatic fuze handler. The fuzes shall be manually loaded onto a circular rotating table which indexes the fuze to the test set. The fuzes shall be tested and ejected to a segregated location if they fail the test. The material handler shall return the fuzes which pass the tests to the operator for unloading.

4.8.2.3 CRT Terminal with Keyboard -- The CRT, complete with keyboard, shall provide operator-controlled displays of the test data and operator interface with the computer/controller as required for operation of the station.

The test station shall incorporate operator initiated built-in automatic self-check tests which will isolate approximately 75 percent of all possible test equipment failures. Calibration failures are excluded from this requirement. Detected failures by the self-check test shall be identified per the functional block (figure 39) that requires repair.

4.9 Crimp Station

The crimping of the electronics and nose cone assembly into the rear fitting assembly shall be accomplished at this station. The station shall be designed for a minimum net capacity of 100,000 units per month on a 1-8-5 production basis or 290,000 units on a 3-8-7 production basis, allowing for all expected equipment downtime for maintenance and repair.

The electronics and nose cone assemblies pre-assembled to rear fitting assemblies shall be manually loaded into the 24-station dial-index table. The dial-index table shall carry the units for crimping, after which the units shall be manually unloaded from the table and sent to the next operation.

The equipment that comprises this station shall be Abex-Denison hydraulic presses with a rotating dial-index table. It shall also have the following requirements:

• Capacity	- 10-15 tons.
• Series	- FW or WS.
• Model	- Floor or bench optional.
• Control valves	- C97E/M7 automatic repeat.
• Reservoir capacity	- 20 gallons maximum.
• Stroke (adjustable)	- 6 inches maximum.
• Rate	- 190 strokes per minute.

5. QUALITY ASSURANCE

5.1 Quality Assurance Program Plan for Production

Honeywell's quality assurance system is a total system designed to satisfy the requirements of MIL-Q-9858A and related specifications; i.e., MIL-I-45208A and MIL-C-45662. The system will ensure that all XM587E2/XM724 fuze quality assurance requirements are effectively and economically satisfied.

Honeywell's overall quality assurance system also encompasses most of the specific requirements of MIL-Q-9858A. In instances where it presently does not meet those requirements, the detailed program quality assurance plan will make provisions to ensure full specification compliance.

The objective of Honeywell's quality policy is t cate and deliver quality products. To achieve this objective, ality policies of the Honeywell Defence Systems Division are base he fundamental concept that control of quality is a team obligat and that quality products are produced only when all team m nbers strive toward this common goal. Our team consists of every employee of the Divison, whether directly involved in the design, manfacture, or service of t product, or in support of these direct activities.

The Quality Assurance Engineering department is a part of the team. It is directly responsible for the quality of products shipped from the Division. The specific policies of the Quality Assurance Engineering department are as follows:

- Provide quality assurance perspective to product designs, incorporating features to permit an economical assessment of product quality.
- Establish a cost-effective quality assurance program which encompasses all aspects of quality control as they relate to the contractual requirements. Maintain an audit system to ensure continued effective maintenance.on all program elements.
- Establish controls necessary to ensure that only quality materials and components of the proper configuration are used in our process and products.

- Promote defect prevention through systematic control of processes and personnel, utilizing sound statistical control practices, properly-calibrated equipment, timely corrective actions, and properly trained personnel.

- Promote a quality attitude among employees at all levels to achieve a quality product.

- Apprise management of current quality status by providing effective evaluation and reporting techniques.

- Achieve customer satisfaction through economic on-time delivery of a quality product, product field performance assessment, and appropriate corrective action.

The system is continually evaluated for both content and compliance by resident DCAS personnel. The primary tasks involved in developing Honeywell's XM587E2/SM724 fuze quality assurance program include the following:

- Technical data analysis (determine quality needs).

- Classification of characterisitics (performed jointly with Reliability, Design, and Production Engineering to identify critical, major, and minor drawing characteristics).

- Initial quality planning (define quality approach).

- Acceptance plans for automated assembly machines.

- Inspection plans for machines and product.

- Configuration management planning.

- Procured material quality assurance.

- Preproduction planning.

- In-plant manufacturing process quality assurance.

- Final acceptance and shipment.

All quality tasks shall be accomplished in accordance with Honeywell's Defense Systems Division quality assurance procedures.

5.1.1 Organization -- The Reliability and Design Support (R&DS) Engineering group and the Quality Assurance Engineering department are separate functions in the Honeywell Defense Systems Division. The R&DS Engineering group reports up to the Director of Engineering; the Quality Assurance Engineering department reports to the Director of Quality Assurance. The primary function of the R&DS Engineering group is to support the design process in ensuring that the final product definition is compatible with all contractual reliability, maintainability, and system safety requirements and Honeywell policy. The primary responsibility of the Quality Assurance Engineering department is to ensure that components and assemblies conform to contractual specifications and requirements, and to related engineering documentation.

5.1.2 Inspection System   An inspection system in accordance with MIL-I-45208A is maintained by Honeywell. As an integral part of this inspection system, a calibration system in compliance with MIL-C-45662 is also maintained.

Quality Assurance Engineers shall prepare and coordinate the execution of the inspection plans, which shall be designed to ensure product and equipment compliance with the contractual requirements.

Acceptance inspection shall be accomplished by qualified personnel using documented inspection procedures generated by the Quality Assurance Engineers. Records of tests, calibration, and other quality control activities shall be maintained. The records shall include corrective actions taken. These records shall be made available to Government personnel upon request for the duration of the contract.

5.1.3 Measurement and Test Equipment -- All measurement and test equipment, including gages, setup masters, inspection probes, and automated test equipment for the S&A module and fuze automated assembly lines, are all under the surveillance of the Quality Assurance Engineering department. Measurement and test equipment shall be calibrated periodically against standards which are traceable to the National Bureau of Standards (NBS). Calibration frequencies shall be established on the basis of experience with similar equipment. All properly-calibrated measurement and test equipment or probes shall be identified as to its intended use and its calibration status. Software-controlled equipment shall be calibrated according to approved written calibration procedures. All software programs used for product acceptance are controlled in accordance with departmental software control procedures by the Quality Assurance Engineering Department.

5.1.4 Material Control and Identification -- The Quality Assurance Engineering department, through written procedures, ensures that all parts, subassemblies, assemblies, and bulk and raw materials are identified at the point of initial inspection. Thereafter, such material shall maintain this identity into subsequent assembly.

Nonconforming material shall be segrated and removed from normal production channels. It shall be analyzed to determine the cause of the discrepancy. Corrective action shall be initiated when the discrepancy is repetitive and is due to an assignable cause.

Disposition of nonconforming material is determined within the framework of the authority granted to Honeywell in the contract or purchase order.

5.2 Machine Development and Acceptance Phase

5.2.1 Machine Development -- Quality Assurance Engineers shall particiapte with Machine Design Engineers and Production Engineers in machine design development, fabrication, and debug. Plans and procedures shall be prepared for:

- The inspection, evaluation, and control of machine debug and acceptance hardware.
- The verification of contractual requirements for machine operating efficiency and acceptance criteria.
- The qualification of each inspection station.
- The demonstration of reliability-availability-maintainability (RAM) requirements.

5.2.2 Acceptance of Dial-Index Automated Assembly Machines -- Each index machine shall be subjected to four check point runs - check point 1 is a base machine system run-in, check point 2 is the run-in of completely tooled machines, check point 3 is the qualification of machine inspection stations (stations designated to perform product acceptance inspection), and check point 4 is the final performance run.

5.2.2.1 Check Point 1 - Base Machine System Run-In -- Each base machine system shall be cycled a sufficient number of hours to demonstrate a mean time between failures (MTBF) of 10 hours minimum at 90 percent confidence for the motors, drive train, clutch, cams and linkage.

5.2.2.2 Check Point 2 -- Tooled Machine Run-In -- A dry station cycling test (without parts or subassemblies) shall be run on each machine after all stations are completely attached and tooled and after installation of all feeder bowls and handling, transfer and ejection mechanisms. Each machine shall be cycled a sufficient number of hours to demonstrate an MTBF of 4 hours minimum at 90 percent confidence for the tooled machine.

5.2.2.3 Check Point 3 - Qualification of Machine Inspection Stations -- Each designated inspection station shall be tested for its ability to differentiate between specification/ drawing defined acceptable and nonacceptable units. The station reliability shall be checked by passing known defective units and/or inspection masters through the stations a sufficient number of times to demonstrate an inspection station reliability of 99 percent each at a confidence level of 80 percent.

The goal is to ensure the occurrence of no more than one critical defective part per 1,000,000 parts produced. This will be achieved by controlling product quality to $\leq$ 1 percent defective parts submitted to two redundant inspection stations, each qualified to be 99 percent effective. The goal for special and 100 percent major characteristics is to ensure no more than one defective part per 10,000 parts produced. This will be achieved by controlling product quality to $\leq$ 1 percent defective parts submitted to an inspection station qualified to be 99 percent effective.

The inspection masters shall be precision ground to the characteristic tolerance, usually of the go or no-go type used for setting and verifying the setting of inspection stations.

5.2.2.4 Check Point 4 - Final Performance Run -- Each machine shall be final accepted/rejected on the basis of a performance run. The run shall be conducted at Honeywell. In cases where Honeywell is both the machine builder and the basic production facility contractor, the machine acceptance shall be made prior to the machine's release from the machine build area.

During the performance run, each machine shall demonstrate a productivity as specified in the individual machine specification and agreed to in the contract or purchase order.

The performance run shall be conducted under conditions that, as close as practical, simulate the planned automated assembly line environment relative to operators per machine, parts loading into and out of machine, and the quality of the parts being used.

All parts and subassemblies used during the performance runs shall be of an acceptable quality level, based upon their having passed sampling inspection. The machine builder shall have the option of fine tuning the machines prior to the performance run using parts and subassemblies from the same lot as will be used in the performance run. The machine-induced scrap rate during the performance run should be no greater than specified in the individual machine specification.

During any of the check point runs, an automated assembly machine failure is defined as any production stoppage which requires repair maintenance personnel action due to a breakage, misalignment or malfunction of any machine component.

5.2.3 Acceptance of Automated Electronic Component Sequencing/ Insertion Equipment

5.2.3.1 Preliminary Acceptance -- Preliminary machine acceptance shall be determined on the basis of a preliminary acceptance run at the supplier's facility. This run must be witnessed and approved by the procuring activity prior to machine shipment.

Each tooled machine shall demonstrate a continuous test run at a cycle rate equal to or better than the machine assembly rate stated in the respective specifications. This run shall be conducted without feeding or assembling parts for an 8 hour period without a failure. A failure is an unscheduled stoppage requiring a skilled person other than an operator to correct.

5.2.3.2 Final Acceptance -- Final machine acceptance will be determined on the basis of an acceptance run at a designated customer plant. The acceptance run shall be conducted using customer-supplied parts and/or subassemblies. The machine will demonstrate a capability of fabricating a quantity of units equal to 1 hour's production output within a 2-hour period. During the acceptance run, the machine-caused defects shall meet the requirements of the respective specification.

Acceptable and/or rejected hardware will be determined by the customer of the finished units evaluated against the appropriate drawing/specification requirements, as defined in the contract or purchase order. The acceptance run shall be conducted with the same number of technically capable operators as required in production. Any stoppage during the acceptance run, which requires the service of tool makers or other skilled trades to correct/adjust the machine, will terminate the run and will require a new run when needed corrections are completed.

5.2.4 Acceptance of Automated Test Equipment -- A qualification plan shall be prepared to demonstrate, as a minimum, the equipment accuracy, testing rate, product yield, test repeatability, software/hardware compatibility, and compliance with the contract and specification requirements.

Acceptance of the test equipment shall be granted upon a successful qualification run. The qualification run, which includes data correlation and equipment efficiency verification, shall be conducted with a predetermined number of assemblies.

The equipment efficiency verification run shall consist of the testing per the individual specification. Any stoppage during the run which cannot be corrected by the operator shall terminate the run and shall require a new run when needed corrections are completed. The success of the verification run shall be based upon inspection of the test data and the tested units, to determine the product yield as defined in the respective specifications.

5.2.5 Acceptance of Wave Soldering Machine -- Preliminary system acceptance shall be determined on the basis of a preliminary acceptance run at the supplier's facility. This run must be witnessed and approved by the procuring activity prior to system shipment.

The system shall demonstrate a continuous test run as required by the machine specification.

Final machine acceptance will be determined on the basis of an acceptance run at a designated procuring activity plant. The acceptance run shall be conducted using procuring activity supplied parts and/or subassemblies. The machine will demonstrate a capability per the machine specification. Acceptance and/or rejected hardware will be determined by the customer of the finished units against the appropriate drawing/specification requirements as defined in the contract or purchase order. The acceptance run shall be conducted with the same number of technically capable operators as required in production. Any stoppage during the acceptance run which requires the service of too makers or other skilled trades to correct/adjust the machine will terminate the run, and will require a new run when needed corrections are completed.

5.2.6 Acceptance of Encapsulation Equipment -- A preliminary acceptance run shall be conducted at the machine builders facility to demonstrate the required output rate for the dispensing equipment and the stability of the heating equipment. The dispensed potting compound shall be inspected for compliance with the specification requirements.

After the dispensing system is installed in the basic production facility, a final acceptance run shall be conducted on the total system using production hardware supplied by the basic production facility. contractor. During this run, the equipment must be capable of producing as required by the machine specification.

The encapsulation equipment shall be accepted according to the criteria set forth above, the acceptability of the encapsulated electronics and nose cone assemblies (Part Number 11711430). Acceptance inspection shall be performed with properly calibrated and approved inspection equipment and shall include:

- Proper mix and uniform distribution of the base mixture and the hardener.
- Proper metering (correct ratio and volume) of the base mixture and the hardener.
- Proper mixing of the potting compound.
- Proper functioning of the presence and position probe(s) or similar sensor(s).
- Proper output yield.
- Proper product yield.
- Proper potting compound physical properties.
- Proper fill of the electronics and nose cone assemblies.

5.3 Production Phase

5.3.1 Calibration of Inspection Stations -- Precision inspection station masters shall be used to demonstrate the calibration status of each 100 percent functional test station and each 100 percent dimensional check station. Special inspection procedures shall be prepared and adhered to for checking probing stations where masters are either not feasible or not necessary. The verification and the recalibration of each inspection station shall be conducted at predetermined frequencies as dictated by the reliability data gathered on each station.

5.3.2 Machine Log and RAM Prediction Update -- During the initial production phase, a log shall be maintained on each machine, Reliability-availability-maintainability (RAM) data shall be gathered for the purpose of updating the preliminary RAM predictions.

5.3.3 Product Acceptance Inspection

5.3.3.1 Procured Material -- The assigned Quality Assurance Engineer shall establish the controls which will ensure that procured material will comply with all contractual requirements and will perform their intended functions. A number of electrical components, explosive elements, and the potting compound used in the fuze require initial qualification and periodic lot acceptance testing (LAT). Suppliers of these items shall be surveyed by the Quality Assurance Engineering Department as to their capability to perform the required testing. A plan shall be prepared to coordinate all the testing activities and to ensure conformance with the respective specifications and timely delivery of the material. Typically, a lot shall be placed in controlled storage and not be released for production use until the results of the LAT are available.

5.3.3.2 In-Process Material -- Inspection procedures shall be prepared for the points of inspection identified throughout the manufacturing process. These procedures shall be continually monitored for accuracy, completeness, and operator compliance. Inspection shall be performed either on a lot sampling or a continuous sampling basis, depending upon the type of machine or operation

Subassemblies and assemblies shall be inspected and tested in accordance with their respective classification of defects and LAT requirements. Subassemblies shall be inspected and placed in controlled storage until the LAT results are available.

5.3.4 Data Acquisition -- As part of the assembly of the XM587E2/XM724 fuzes, specific types of data must be obtained and processed. The data to be acquired are defined for the major items by the following specifications:

Item	Specification
S&A module assembly	11720300
Rear fitting assembly	11720291
XM587E2/XM724 fuzes	MIL-F-48700
Electronics and nose cone assembly	11711430

The following types of data shall be furnished for each lot.

5.3.4.1 Classification of Defects Data.-- Some of the classification of defects inspections will be accomplished off-line from the XM587E2/XM74 fuze automated assembly line. Evaluation of the features identified in the specification control drawings reveals that certain of the required inspections can best be accomplished by bench-type inspections.

The Production department will accumulate finished product items until the lot quantity reaches a specified size that is compatible with the contractor's process/facility, at which time the lot will be submitted to the Inspection department. The Inspection department will select a random sample from the total lot and perform the required classification of defects inspections, recording the attribute inspection data on the inspection data record form (sample size, accept/reject numbers, numbers of defective units, and all pertinent lot information). The inspection data will then be transferred from the inspection data record form onto magnetic tapes for formal submission.

The planned analysis of the attribute inspection data will be limited to various percent defective calculations, such as lot to lot, process, and cumulative.

5.3.4.2 Variables Data -- Variables data on the electronics and nose cone assemblies shall be recorded on 800-bit-per-inch, nine-track 1/2-inch computer tape on 2400-foot standard reels and hubs.

5.3.5 Packing and Shipping Control -- Written inspection procedures shall be prepared for inspection during packing and shipping. Packing inspection shall include packing methods, identification, count, proper marking of containers, and container damages. Shipping inspection shall include inspection for conformance with approved methods of loading and storing in a common carrier. Ammunition data cards shall be provided on products shipped in accordance with MIL-STD-1167.

6. RELIABILITY AND SAFETY

6.1 Reliability-Availability-Maintainability (RAM)

Honeywell's philosophy of automated multimachine automated assembly lines utilizes the concept of modularized multi-station automated assembly machines. This philosophy is based on the experience that Honeywell has gained as designer, builder, and user of automated assembly and inspection machines for high-volume automated assembly lines. The modularized automated assembly machines are united into a production system through the application of input-output part and subassembly storage capabilities between machines. The quantity of parts or subassemblies stored is a function of several factors including safety (explosive storage limitations) and economics (cost of subassembly inventories). The utilization of these storage capabilities results in a production system which essentially consists of independent modularized automated assembly machines.

The practice of incorporating independent modularized automated assembly machines into an automated assembly line has resulted in a more positive production capability. During those time periods when an automated assembly machine is undergoing repair, the automated assembly line has the capability of continuing production of the given product. This capability becomes readily apparent when the process flow diagrams presented in this document are considered. The automated assembly machines which produce the S&A module offer an example of modular, independent operation and resultant production system effects.

The acceptable S&A module assemblies from machines S10-1 and S10-2 are ejected into magazines and subsequently supplied to machine F4 (rear fitting assembly operation 2). A temporary stoppage (failure and failure repair time) of machine F4 does not require termination of production from machines S10-1 and S10-2 unless their continued output surpasses the storage capability; i.e., specified limitations or available empty magazines. In like manner, the operations occurring at bench 4 (manual assembly, E-head to rear fitting assembly) will continue until the available supply of rear fitting assemblies is expended. Conversely, a stoppage of machine S10-1 or machine S10-2 or both will not require immediate termination of production from machine F4. Assembly of rear fitting assemblies can continue until the stored quantity of S&A module assemblies is depleted or until ma[illegible]ne F4 experiences a production stoppage. Considering the process [illegible]ow diagrams and the single and multiple machine stoppages discussed above, there is no necessity for system stoppage; i.e., production of the given product continues.

The time duration of the capability of the automated assembly line to continue production when a subassembly automated assembly machine is in a repair mode is not unlimited. Automated assembly line production output time is influenced by the stored quantity limitations, the individual automated assembly machine failure frequency and repair times, and the availability of the last automated assembly machine in the line.

For the purposes of initial machine line design work, conservative RAM related factors were assumed for each automated assembly machine in order to ensure compliance with the required automated assembly line production capabilities. For example, machine availability predictions, as contained in Appendix B, an operator efficiency of 0.92, a 50-minute hour work period, and moderate scrap allowances were incorporated in establishing hourly output from each automated assembly machine. An in-depth RAM analysis is contained in Appendix B.

6.2 Design Guidelines

The following design guidelines provide design practices, the implementation of which will improve machine reliability and enhance maintainability, safety, and human factors and minimize environmental effects.

6.2.1 Reliability Design Guidelines -- The following reliability related features are to be incorporated into the design of each automated assembly machine as applicable:

- Each machine will be protected against damage due to defective parts.
- The presence and position of each part will be verified prior to the next assembly operation.
- Each prove-in memory circuit will be programmed to count consecutive rejects and automatically stop the machine and indicate the cause of rejection.
- Acceptable assemblies will be ejected ahead of the machine reject stations for fail-safe operation.
- Acceptable assemblies must receive a go signal from the memory command to be ejected; i.e., memory failure causes rejection.
- All machine bases will be of a standard design (see Appendix A).

- All machine standard parts and materials (cam followers, bearings, motors, springs, air cylinders, valves, etc) will be used below rated capacity for 20-year life expectancy (1-8-5 production basis) (10 years required).

- Machine materials (castings, shafting, wear plates, etc) will be of quality exceeding application requirements; e.g., hardened steel alloy or its equivalent will be used where constant abrasion occurs.

- All castings will be stress relieved or normalized to prevent dimensional changes or warpage throughout machine life.

- Protective finishes (paint, electroplating, black oxide coating, etc.) will be applied to surfaces exposed to environmental deterioration to prevent corrosion during expected life or during storage.

- Seals or wipers will be provided to protect moving parts from foreign materials and undue wear.

- Defects or abnormalities detected by inspection stations will cause the machine to stop or activate another appropriate device.

6.2.2 Maintainability Design Guidelines -- The following maintainability related features are to be incorporated into the design of each automated assembly machine as applicable:

- Interchangeability of components/parts wherever practical.

- Appropriate use of off-the-shelf parts and standard items.

- Minimization of the need for special tools, fixtures, jigs, and test equipment.

- Quick and easy access to and accomplishment of adjustments and repair.

- Good accessibility (including idle stations between major work stations as necessary), especially to periodically replaced items.

- Ease of replenishment of consumables.

- External fault isolation points as appropriate.

- Use of self-test and other features for rapid and positive fault detection and isolation.
- Color coding or marking for easy identification of electrical and fluidic features.
- Use of modular construction where appropriate.
- Safety for maintenance and operation.
- Use of fail-safe features that prevent machine damage.
- Minimization of items requiring maintenance.
- Minimization of preventive maintenance requirements; i.e., items requiring maintenance, frequency of maintenance and labor required, machine down time involved, parts and tools required, spare parts/module requirements, etc.

6.2.3 Safety Design Guidelines -- The automated assembly machine must be designed to prevent hazard to the operator and others associated with the automated assembly line, including maintenance personnel.

A preliminary hazards analysis for the basic production facility as described herein is contained in Appendix C. Each automated assembly machine must also be compatible with the product assembled such that its safety characteristics are not altered unintentionally, as through electrical discharge, damage, etc. Applicable portions of OSHA, AMCR 385-100, and DOD 4145.25M apply. Of particular concern are the following features, all of which are to be incorporated as applicable:

- Shielding of pinch points/impact points and hazardous moving parts.
- Appropriate protection from hazardous materials.
- Interlocks on barricades, etc., where necessary to prevent injury.
- Appropriate emergency and automatic shutoffs.
- Warning lights/alarms/signs/decals where necessary.
- Electrical grounding of machine.

- Noise levels below 85 decibals at each operator position during line operation.

- Maximum weight of loaded magazines/trays acceptable for female operators.

- Provisions for safe removal of parts and machine repair.

- Adequate protection from dangerous electrical shock provided for maintenance personnel.

- Appropriate protection of personnel and property from explosives and hazardous materials during handling, processing, and storage.

- Explosive barriers and conveyor spacing.

- Equipment located such that access by personnel during operation, maintenance, or adjustment will not require exposure to hazards such as chemical burns, electrical shock, ionizing and non-ionizing radiation, cutting edges, sharp points, or toxic atmospheres.

- Disposal and storage of scrap explosives and other hazardous materials.

- Suitable and inclusive warning and caution notes for operation and maintenance instructions.

- Shielding of personnel from non-ionizing radiation (laser) if needed.

- Shielding of electric detonators from radio frequency radiation.

6.2.4 Human Factors Engineering (HFE) Design Guidelines -- Human factors must be considered throughout the automated assembly machine design effort to help optimize operation efficiency. HFE guidelines, such as described in MIL-STD-1472A (Human Engineering Design Criteria for Military Systems, Equipment and Facilities), are to be utilized wherever practical in the design and layout of the automated assembly machines. Each of the following human factors features is to be incorporated on newly designed automated assembly machines as applicable:

- Displays and controls at optimum locations, utilizing HFE guidelines where possible.

- Descriptive legends on or near every control and display.
- Station lights corresponding to station numbers.
- Automatic feeder bowl shut-off with machine shut-off (manual override).
- Consistency in displays and controls for a given function.
- Knobs, handles, dials, switches, buttons, cranks, and other controls consistent with HFE guidelines.
- Signs, displays, lights, and other signals consistent with HFE guidelines.
- Quick and easy, yet safe, access to machine areas requiring operator access.
- Magazines and trays easy to handle and all consumables easily replenished.
- Operating instructions and training for normal operation, malfunctions, and emergencies.
- Feature for easily verifying operability of warning lights, etc.
- Quick and easy adjustment of parts likely to require adjustment.
- Access doors, openings, covers, latches, etc. in accordance with HFE guidelines.
- Any special precautions clearly indicated in an appropriate place on the machine and in a manual.
- Features for safe manual operation (jogging) of the machine.
- Acceptable environmental conditons; e.g., noise, vibration, illumination, and stress.
- Fail-safe features to prevent damage to machine in case of malfunction or human error.

6.3 Special Handling Requirements

There are two types of components that will require special handling. One involves the explosives (detonators, leads, and boosters) and

the other involves electrostatic-sensitive electronic components such as the two integrated circuits. The first requires use of normal explosive handling precautions and compliance with such documents as the DOD Contractor's Safety Manual (DOD 4142.25M) and the AMC Safety Manual (AMCR 385-100) as well as applicable OSHA regulations which require approved operating procedures for explosive handling.

Special handling requirements and procedures for electrostatic-sensitive electronic components and assemblies are newer and less standardized than for explosives. Appendix D contains an Engineering specification (ES 8708, Handling of Electrostatic Sensitive Items) which will be used as a guide for the handling of components on the XM587E2/XM724 fuzes.

6.4 Automated Assembly Line Concerns for Product Safety

To ensure that the assembled fuze is safe to handle, it is imperative that the S&A module assembly rotor be in a safe position. If the S&A module assembly is armed, the explosive train could initiate if the fuze were dropped since the firing pin is then over the stab detonator.

Precautions will be taken in designing the automated assembly machines to ensure with a high degree of confidence that the S&A module will be in the safe condition after assembly and that an armed S&A module cannot be assembled to the rear fitting assembly.

To ensure that the S&A module is safe, redundant 100 percent probe stations are used on the automated assembly machines for critical (safety) characteristics. For example, machine S9 [S&A module assembly operation 1 (arm check)] will include the following safety checks after the 1700-rpm spin function and re-safe operations:

- Probe 100 percent for armed S&A modules and reject any that are found.
- Spin to 1100 rpm for a nonarm test.
- Probe 100 percent the nonarm rotor position.
- Probe 100 percent the nonarm rotor position a second time.
- Reject any defective S&A modules from the above operations to a locked container.

Also, for assembly of the S&A module assembly to the rear fittings assembly, the tooling will be designed such that an armed S&A module assembly cannot be picked up, thus further ensuring that the fuze will be safe.

7. PLANT LAYOUT AND MATERIAL CONSIDERATIONS

7.1 Plant Layout

The assembly of the XM587E2/XM724 fuze and S&A module will be performed in a single enclosed work area encompassing 63,000 square feet. The overall plant layout is shown in figure 40. The overall plant layout is arranged such that there will be a continuous logical flow of materials beginning at the production stock cribs. Materials will then proceed through the various assembly areas. Final inspection, packing, and shipment will occur at the end of the assembly process. The service facilities, office, and other support activities are located in the center of the area to facilitate interfacing activities with all the assembly and work areas.

In addition to the service facilities defined in the overall plant layout, other support facilities are assumed to be available. Such facilities include the following:

- Chemical and metallurgical laboratory.
- X-ray facilities.
- Failure analysis laboratory.
- Evaluation laboratory.
- Government agency offices.

The layout of the specific assembly areas have been established such that there is adequate spacing between the machines and work areas to allow unobstructed operator movement. In addition, the provision has been made in assembly areas for operator safety when hazardous material is handled, including special ventilation for the encapsulation area, temperature control in all assembly areas, plus humidity control in final fuze assembly and pack area.

The layout of the individual assembly areas reflect the flow diagrams presented in sections 3 and 4. The identification of the various machine and assembly operations as depicted in the plant layouts is shown on table I. Plant layout details are shown in figures 41 and 42.

7.2 Material Storage for Fuze Automated Assembly Line

The following three levels of storage merit consideration:

- Printed wiring board subassemblies awaiting the next operation.

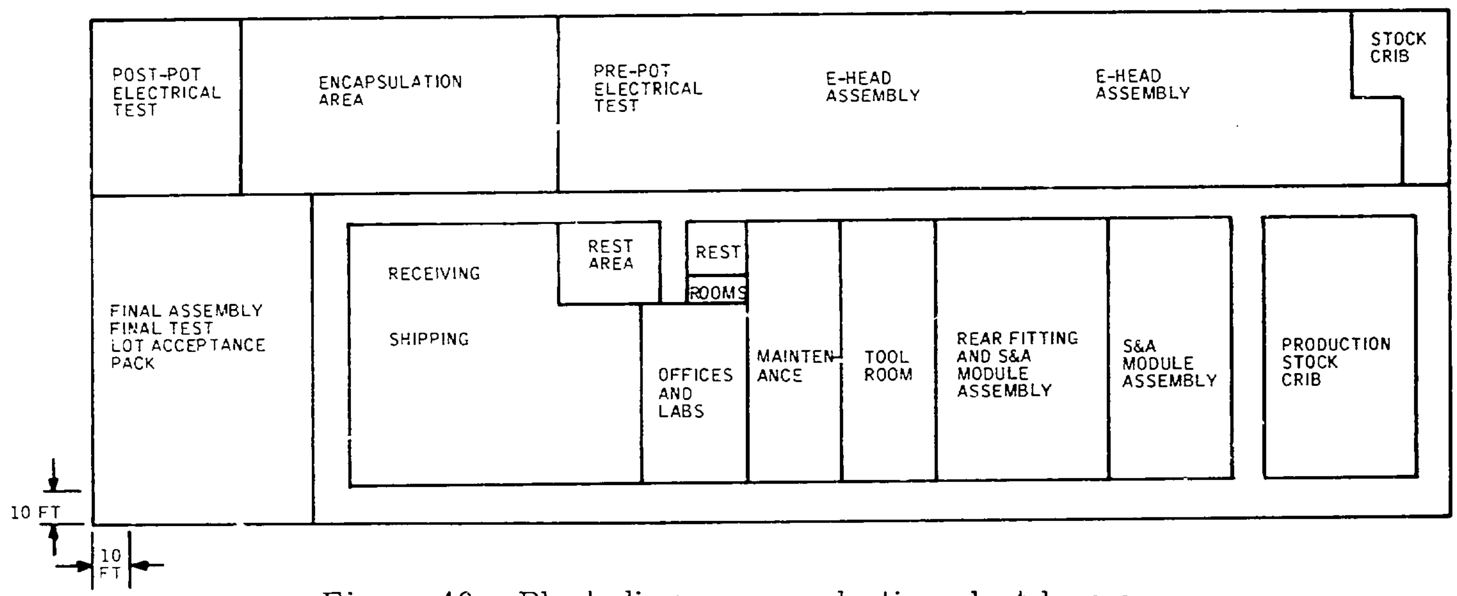


Figure 40. Block diagram, production plant layout

TABLE I. IDENTIFICATION OF VARIOUS MACHINES AND ASSEMBLY OPERATIONS DEPICTED IN THE PLANT LAYOUTS

Plant Layout Identification	Description	Report Reference Section
S1	S&A Module Lower Subassembly Operation 1	3.2.1
S2	S&A Module Lower Subassembly Operation 2	3.2.2
S3	Lower Plate and Shaft Assembly	3.2.3
S4	Lock Pin Spring Winder	3.2.9
S5	S&A Module Subassembly Operation 1 (Gear Train)	3.2.4
S6	Rotor Assembly	3.2.5
S7	Spinlock Spring Winder	3.2.9
S8	S&A Module Subassembly Operation 2 (Lead Cup)	3.2.6
S9	S&A Module Assembly Operation 1 (Arm Check)	3.2.7
S10	S&A Module Assembly Operation 2 (Setback Pin)	3.2.8
S11	Setback Spring Winder	3.2.9
E1	Electronic Cover and Orientation Cup Assembly	4.6.1
E2	Setting Ring and Nose Plug Assembly	4.6.2
E3	Electronics and Nose Cone Assembly	4.6.3
E4	Nose Cone Trimming	4.6.4
F1	Detonator Block Assembly Operation 1	4.6.5
F2	Detonator Block Assembly Operation 2	4.6.6
F3	Rear Fitting Assembly Operation 1	4.6.7
F4	Rear Fitting Assembly Operation 2	4.6.8
F5	Crimp Station (Crimp E-Head to Rear Fitting Assembly)	4.9
Bench 1	Manual Assembly, Printed Wiring Board 1	4.5.1
Bench 2	Manual Assembly, Printed Wiring Board 2	4.5.2
Bench 3	Manual Assembly, Electronics	4.5.3
Bench 4	Manual Assembly, E-Head to Rear Fitting Assembly	4.5.4
AS1	Component Sequencer, Printed Wiring Board 1	4.2.1
AS2	Component Sequencer, Printed Wiring Board 2	4.2.1
AS3	Axial-Leaded Component Inserter, Printed Wiring Board 1	4.2.2
AS4	Axial-Leaded Component Inserter, Printed Wiring Board 2	4.2.2
AS5	Transistor Inserter, Printed Wiring Board 1	4.3.3
AS6	DIP Integrated Circuit Sequencer/Inserter, Printed Wiring Board 2	4.2.4
Punch Out	Printed Wiring Board 1	4.4
Punch Out	Printed Wiring Board 2	4.4
Wave Solder	Wave Soldering Machine	4.3
Potting Dispenser	Encapsulation System	4.7
T1	Pre-Pot Tester	4.8.1
T2	Post-Pot Tester	4.8.1
T3	Set and Interrogate Station	4.8.2

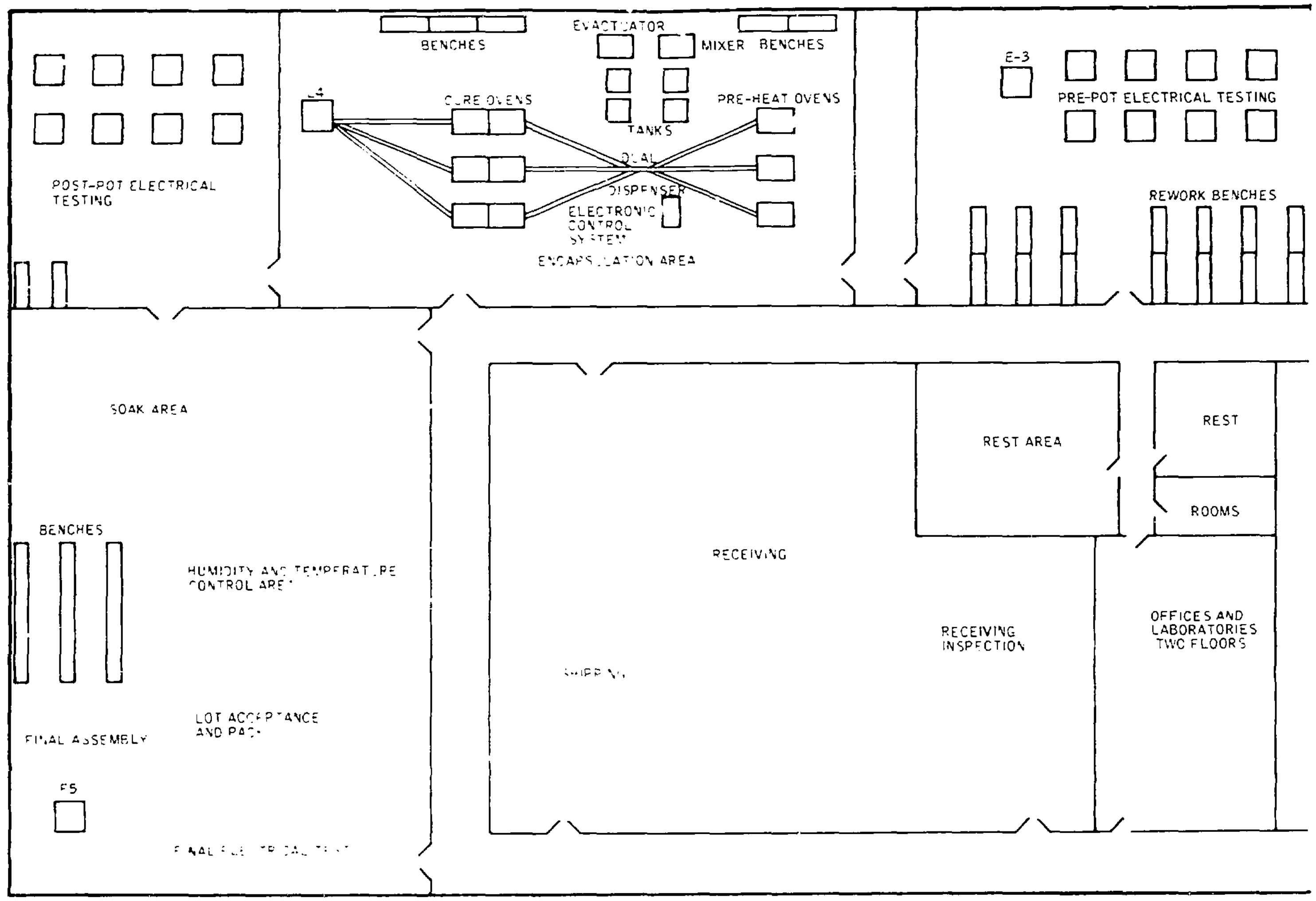


Figure 41. Detailed plant layout, view 1

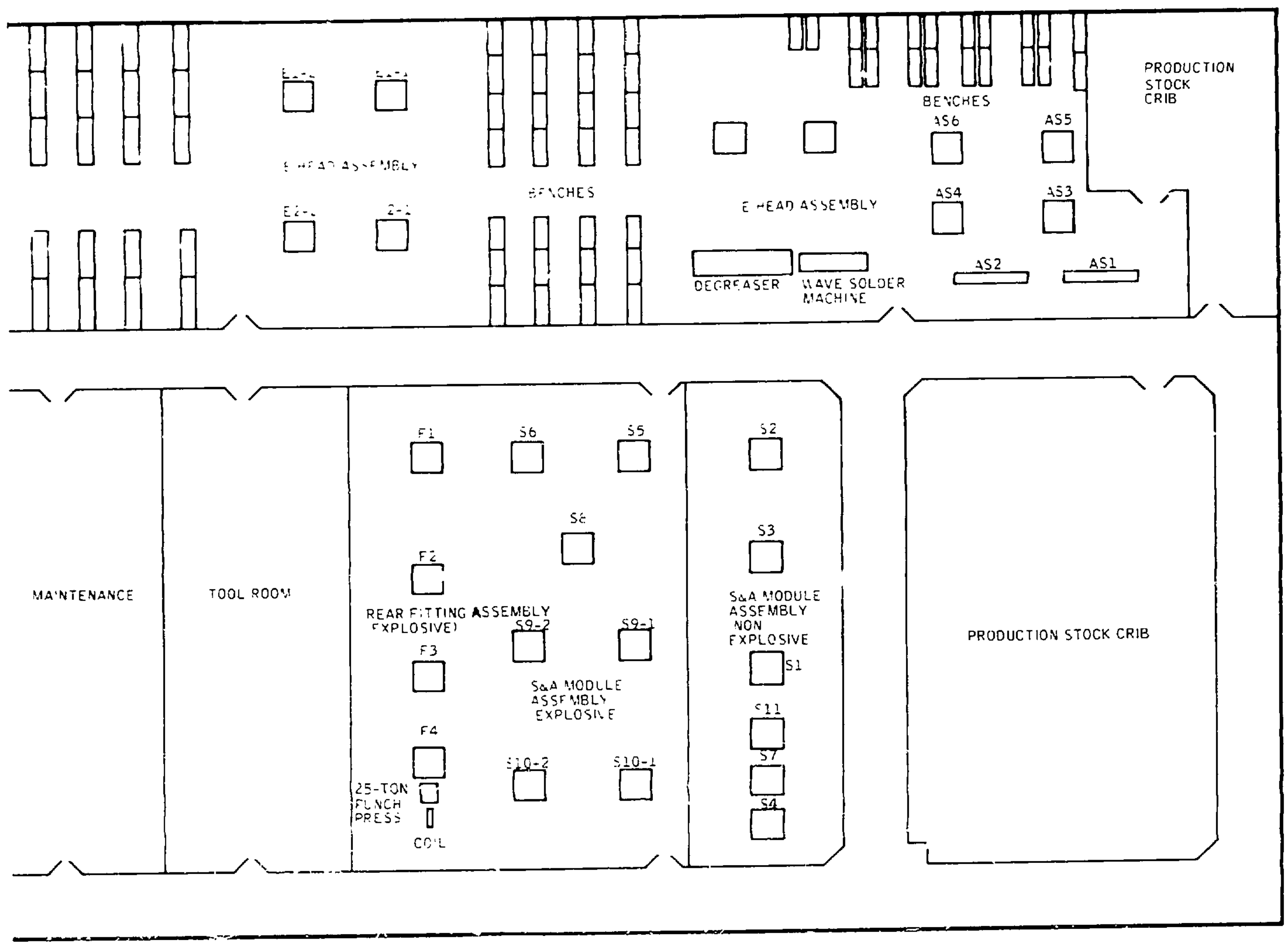


Figure 42. Detailed plant layout, view 2

- Electronics and nose cone assembly awaiting the results of lot acceptance testing (LAT).

- Final fuze, electronic time, awaiting the results of LAT.

The following paragraphs describe the means of accomplishing these levels of final assembly and subassembly storage with regard to the XM587E2/XM724 fuze high-volume production program.

Printed wiring boards 1 and 2 will be stored in trays measuring 24 x 16 x 12 inches. These trays will be made of corrugated cardboard and they will contain separate compartments for each printed wiring board assembly carrier. The carriers will be placed upright into the trays and will provide protection for the electrostatic-sensitive components by making a buffer between the tray and the printed wiring board containing these components. Each tray will accommodate two rows of similarly packed printed wiring board assemblies. The tray will be designed to allow stacking.

These trays will be used to hold the carriers coming off the automated electronic component insertion equipment and through to the wave soldering of carriers and finally ending at the punch out operation. A color-coded identification system will be used to minimize stores handling problems.

The electronics and nose cone assembly, commonly referred to as the E-head, is the digital timing mechanism of the fuze. The lot of these units submitted for production quality assurance must be stored during the acceptance testing of the lot sample.

Storage at this level will be accomplished in plastic molded trays which have a capacity of 12 E-heads. These trays will be used for storing the electronic assemblies after they have been staked into the nose cones, potted, trimmed, and tested.

The final level of storage is the fuze, less booster pellet and cup. At this level, the lot of units submitted to product quality assurance must be stored pending the results of the acceptance testing on the sample drawn from the lot.

Since this is the final level of storage, the fuzes will be stored in the same ammunition cans in which they will be shipped. The ammunition cans are Government furnished. They will be used immediately after the set/interrogate station.

7.3 Material Handling

The handling of the subassemblies and final assemblies of the XM587E2/XM724 fuze is described in the following paragraphs.

All axial-leaded components are sequenced and then taped and reeled. These reels feed the axial-leaded component insertion equipment by which they are inserted onto the printed wiring boards. Similar handling is applied to the transistors. The dual in-line package (DIP) integrated circuits are magazine fed to the automatic DIP integrated circuit inserter and inserted into the printed wiring boards.

The printed wiring board carriers (containing nine printed wiring boards) will be placed in the special trays described above after coming off the inserters. These trays will be used through benches 1 and 2 and the wave soldering operations. A different colored tray will be used for the different operations to minimize stores handling problems.

After wave soldering, the printed wiring board assemblies will be separated at the punch out station. At this station, the printed wiring boards will be guided into metal pans in which they will be taken to the electronics assembly station (bench 3). The subassemblies from this station will be placed in circular trays.

These trays are plastic molded and are compatible with the pre-pot and post-pot functional test equipment. They will have a capacity of 12 units and will facilitate stacking. Again, color coding will be used since the trays, although not identical, are similar in most features. After pre-pot electrical testing, the E-heads are joined with the nose cone and then placed in potting holders. These are again 12-cavity trays, but are rectangular in shape.

These potting holders carry the E-heads through the entire encapsulation process up to the trimming of the fill and evacuation tubes. After trimming, the E-heads will be transferred to the 12-cavity circular trays for post-pot electrical testing. After a lot of E-heads is tested, the lot is stored pending the results of acceptance testing of the lot sample.

The E-heads will then be transferred to bench 4 for assembly onto the rear fitting assembly in 12-cavity trays. After this operation, these subassemblies will be placed into crates for transport to machine F5 (the crimp station). Afterwards, they will be returned to the crates and taken to the set/interrogate station. These crates measure 30 x 15 x 6 inches and have a capacity of 72 units.

When the fuzes are set/interrogated, they will be placed in ammunition cans, supplied by the Government, where they will await the results of the LAT. At the successful completion of these tests, the fuzes will be subjected to final inspection and then packed for shipment.

8. MANUAL ASSEMBLY LINE UNIT PRODUCT COST (UPC) ESTIMATE

A manual assembly line unit product cost (UPC) estimate was generated to assist in determining automated assembly machine amortization and to track the effect of design changes on product cost.

8.1 UPC Estimate Ground Rules

The manual assembly line UPC estimate was based on the following ground rules:

- Baseline data package:
  - S&A module data list (dated 17 December 1975)
  - Rear fitting assembly data list (dated 17 December 1975)
  - Fuze data lists (dated 17 December 1975).
- Government-furnished power supply at $6.31 each.
- Availability of all gages, tools, and test equipment.
- Production at a rate of 100,000 fuzes per month (one shift, 8-hour day, 5-day week) with the average cost of the last 12 months of production after 24 months of production.

The price of the fuze is estimated to be $93.03 with a 15 percent profit. This relates to a fuze cost of $81.71.

A distribution of the cost per work breakdown structure element is shown in figure 43. This figure shows that $53.18, or approximately 66 percent of the fuze cost is accounted for by the two printed wiring board assemblies. Further analysis indicates that $52.79, or approximately 65 percent of the fuze cost is accounted for by seven components. These seven components constitute approximately 88 percent of the fuze material cost. These seven components and their material costs are shown in table II.

8.2 Material and Component Availability

A review of components and raw materials as quoted in the UPC estimate for a production rate of 290,000 fuzes per month starting in mid-1978 can be supported with the following observations:

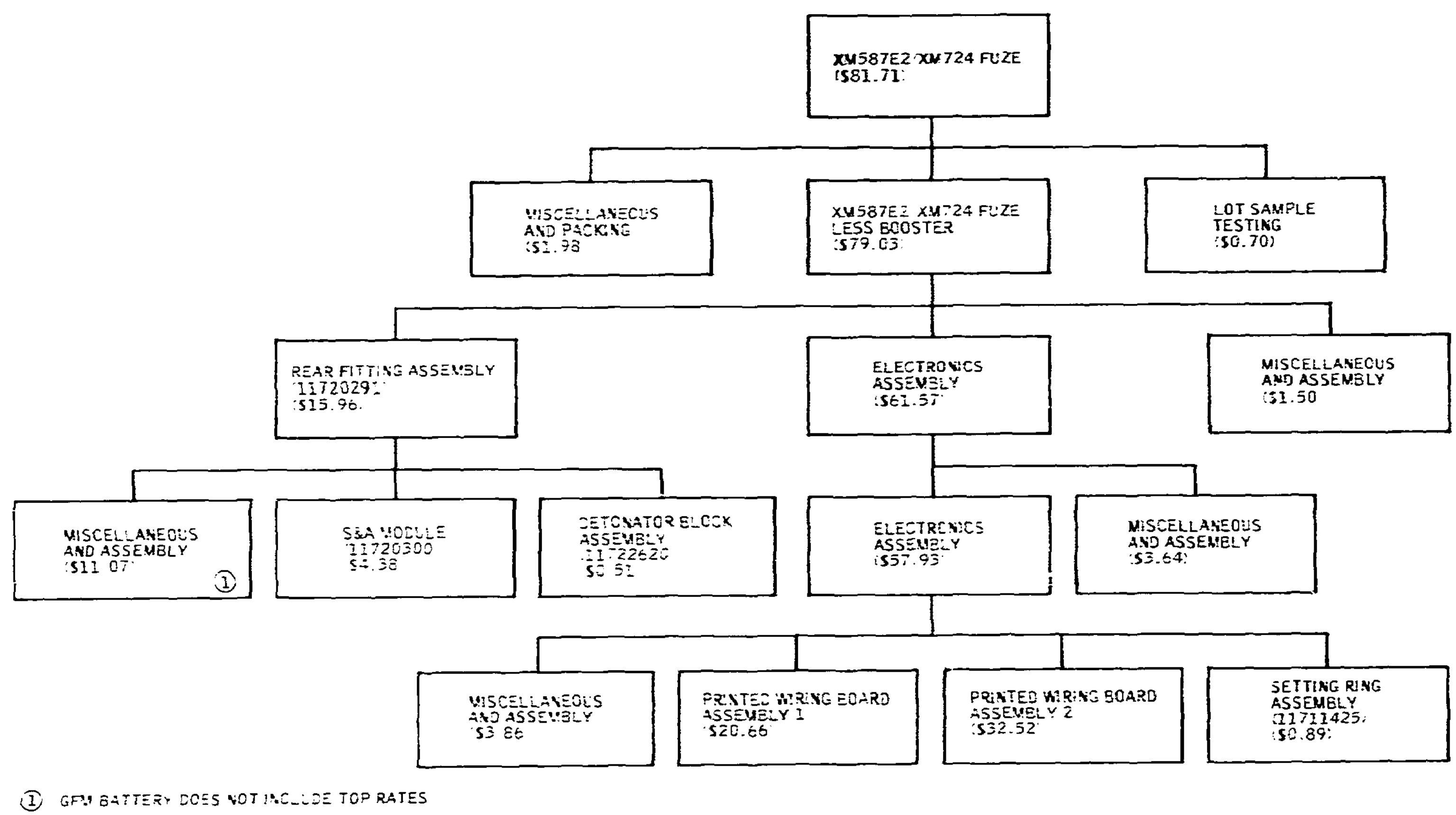


Figure 43. XM587E2/XM724 fuze manual assembly line UPC estimate by work breakdown structure element (G&A level)

- Long-lead-time items:
  - MNOS counter (1099466)
  - Scaler (11711256)
  - Transistor (11711424)
  - Transformer (11711448)
  - Interface circuits (11711610)
  - Oscillator (11711625)
  - Bias spring (11720296-1).
- Materials in short supply - no problems are foreseen in this area.

TABLE II. XM587E2/XM724 FUZE MATERIAL COSTS

Item	Material Cost (With G&A) ①
Integrated Circuit (Counter/Memory)	$ 7.87
Integrated Circuit (Scaler Logic/ Overhead Safety)	$ 5.91
Integrated Circuit (Oscillator Hybrid)	$14.72
Integrated Circuit (Interface Hybrid)	$13.44
Power Supply (GFM)	$ 6.31 ②
Nose Cone	$ 1.93
Rear Fitting Sleeve	$ 2.61
Total	$52.79 (88 percent) ③
Total Fuze Material Cost	$60.23 (100 percent)

① Cost data for these items were obtained from vendor quotations using 1976 rates.

② GFM power supply does not include top rates.

③ Material costs for the seven listed items constitute 88 percent of the total fuze material cost.

In most cases, no one vendor will be able to support this level of production. Therefore, it is imperative to make certain that a minimum of three or more approved and qualified vendors, where possible, are ready when this program is initiated.

8.3 Manual Assembly Line UPC Estimate Per Machine Operation

The manual assembly line UPC estimate has been adapted to show the manual assembly line cost of the machine operations. This adaptation will be used to determine automated assembly machine amortization. The manual assembly line UPC estimate per machine is shown in table III. These data were used to compare with data shown in section 9.

It must be pointed out that the total costs by cost element do not match the cost elements in figure 43. Since the sequencing of operations on the manual assembly line are significantly different from the automated assembly line, it is extremely difficult to break out the direct labor and support effort to tie it exactly to the cost elements of figure 43. Also, the rounding and lumping of costs have made this direct comparison difficult. However, the total at the cost line is within 0.1 percent.

TABLE III. MANUAL ASSEMBLY LINE UPC ESTIMATE PER MACHINE OPERATION

	Machine Operation														
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	E1	E2	E3	E4
Manual Assembly	0.13	0.24	0.12		0.57	0.16		0.19	0.22	0.13		0.39	0.56	0.37	0.19
Part Fabrication	0.26	0.18	0.41		0.22	0.04		0.01	---	0.01		0.29	0.02	0.44	---
Material	0.03	0.14	0.04	0.003	0.20	0.22	0.003	0.19	---	0.01	0.002	0.30	0.14	1.51	---
Support	0.02	0.03	0.03		0.05	0.02		0.02	0.01	0.01		0.05	0.04	0.12	0.01
Total	0.44	0.59	0.60	0.003	1.04	0.44	0.003	0.41	0.23	0.16	0.002	1.03	0.76	2.44	0.20
G&A (19 Percent)															
Total Cost	0.52	0.70	0.71	0.004	1.24	0.52	0.004	0.49	0.27	0.19	0.002	1.23	0.90	2.90	0.24

TABLE III. MANUAL ASSEMBLY LINE UPC ESTIMATE PER MACHINE OPERATION (CONCLUDED)

	Machine Operation								Test Vehicle	Lot Sample	Pack and Ship	Totals
	F1	F2	F3	F4	F5	AS1-AS6	Common Bench	Bench				
Manual Assembly	0.05	0.21	0.14	0.22	0.37	2.78	2.73	1.81	0.01		---	
Part Fabrication	0.19	---	1.41	---	---	---	---	---	---		---	15.07
Material	0.07	6.31 (1) +0.60	1.03	0.02	---	13.94	---	25.20	0.04		1.20	51.20
Support	0.01	0.04	0.13	0.01	0.02	0.84	0.13	1.35	---		---	2.94 0.54
Total	0.32	7.16	2.71	0.25	0.39	17.56	2.86	28.36	0.05	0.55	1.20	69.75
G&A (19 Percent)												
Total Cost	0.38	7.32	3.22	0.30	0.46	20.90	3.40	33.75	0.06	0.65	1.43	81.79

(1) $6.31 cost for power supply does not include top rates.

9. AUTOMATED ASSEMBLY LINE UNIT PRODUCT COST (UPC) ESTIMATE

An automated assembly line unit product cost (UPC) estimate was generated to assist in determining automated assembly machine amortization in comparison to the manual assembly line.

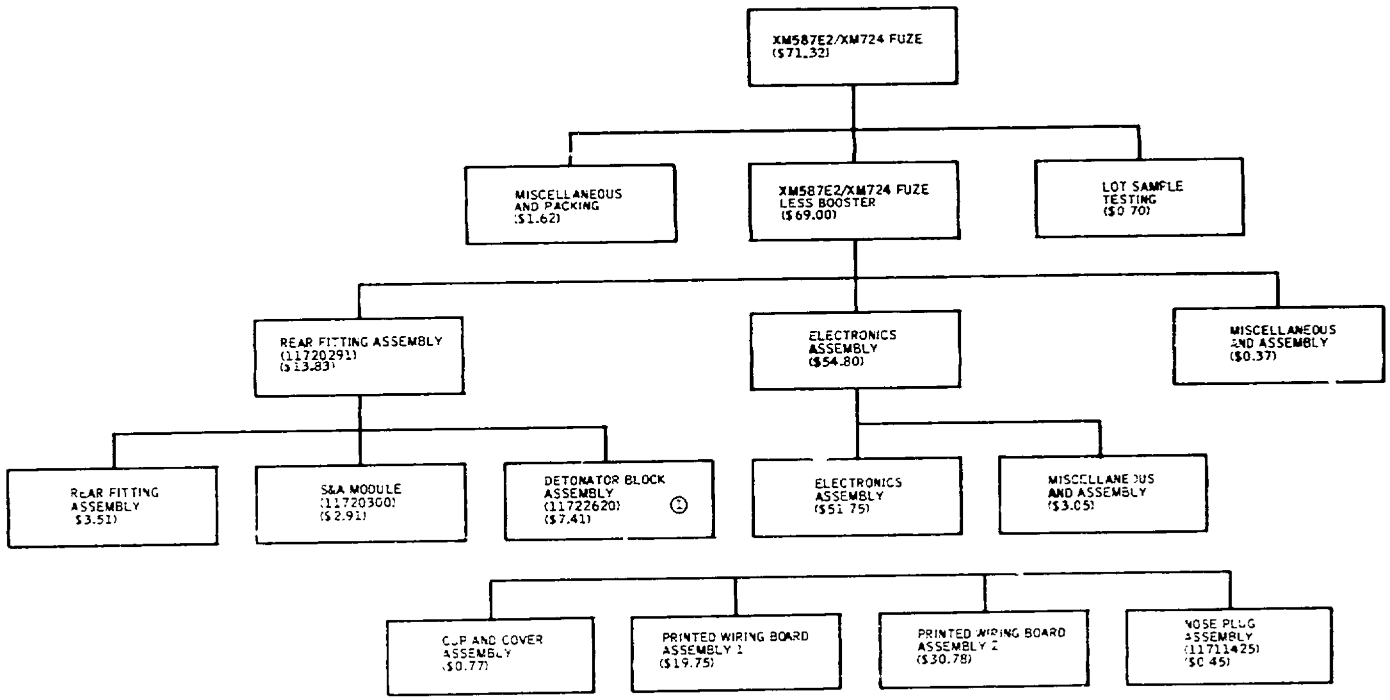
9.1 UPC Estimate Ground Rules

The automated assembly line UPC estimate was based on the following ground rules:

- Baseline data package:
  - S&A module data list (dated 17 December 1975)
  - Rear fitting assembly data list (dated 17 December 1975)
  - Fuze data lists (dated 17 December 1975).
- Government-furnished power supply at $6.31 each.
- Availability of all gages, tools, and test equipment.
- Production at a rate of 100,000 fuzes per month (one shift, 8-hour day, 5-day week) with the average cost of the last 12 months of production after 24 months of production.

The price of the fuze is estimated to be $81.07 with a 15 percent profit. This relates to a fuze cost of $71.32.

A distribution of the cost per work breakdown structure element is shown in figure 44. This figure shows that $50.53, or approximately 71 percent of the fuze cost is accounted for by the two printed wiring board assemblies. Further analysis indicates that $52.79, or approximately 74 percent of the fuze cost is accounted for by seven components. These seven components constitute approximately 88 percent of the fuze material cost. These seven components and their material costs are in table II (see section 8).



① GFM POWER SUPPLY DOES NOT INCLUDE TOP RATES.

Figure 44. XM587E2/XM724 fuze automated assembly line UPC estimate by work breakdown structure element (G&A level)

9.2 Material and Component Availability

A review of components and raw materials as quoted in the UPC estimate for a production rate of 290,000 fuzes per month starting in mid-1978 can be supported with the following observations:

- Long-lead-time items:
  - MNOS counter (1099466)
  - Scaler (11711256)
  - Transistor (11711424)
  - Transformer (11711448)
  - Interface circuits (11711610)
  - Oscillator (11711625)
  - Bias spring (11720296-1).
- Raw materials in short supply - no problems are foreseen in this area.

In most cases, no one vendor will be able to support this level of production. Therefore, it is imperative to make certain that a minimum of three of more approved and qualified vendors, where possible, are ready when this program is initiated.

9.3 Automated Assembly Line UPC Estimate per Machine Operation

An estimate of UPC per machine operation is presented in table IV.

TABLE IV. AUTOMATED ASSEMBLY LINE UPC ESTIMATE PER MACHINE OPERATION

	Machine																			
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	E1	E2	E3	E4	F1	F2	F3	F4	F5
Manual Assembly	0.02	0.02	0.07	0.003	0.10	0.03	0.003	0.04	0.02	0.02	0.003	0.03	0.20	0.04	0.03	0.01	0.02	0.02	0.04	0.02
Part Fabrication	0.26	0.18	0.41		0.22	0.04		0.009		0.01		0.29	0.02	0.20		0.19		1.41		
Material	0.03	0.14	0.04	0.0008	0.20	0.22	0.0006	0.19		0.01	0.0007	0.30	0.14	1.33		0.07	0.60	1.03	0.02	
LBM	0.31	0.34	0.52	0.0038	0.52	0.29	0.0036	0.24	0.02	0.04	0.0037	0.62	0.36	1.57	0.03	0.27	0.62	2.46	0.06	0.08
Support	0.02	0.02	0.03	-	0.03	0.01	-	0.01	-	-	-	0.03	0.02	0.08	-	0.01	0.03	0.13	-	-
Factory Cost	0.33	0.36	0.55	0.0038	0.55	0.30	0.0036	0.25	0.02	0.04	0.0037	0.65	0.38	1.65	0.03	0.28	0.65	2.59	0.01	0.02
G&A (12 Percent)	0.39	0.43	0.61	0.004	0.65	0.36	0.004	0.30	0.02	0.15	0.004	0.77	0.45	1.96	0.04	0.33	0.77	3.08	0.07	0.02
Machine Cost	122772	127068	111173	25861	174229	151756	26802	173630	335060	300961	26187	335601	277830	139062	139676	9137	171416	139649	150671	24640
Total Cost (With 12 Percent G&A)	146099	151211	132296	30773	207343	180828	31894	206620	396331 (2)	358147 (2)	31163	329365 (2)	330617 (2)	163484	166214	10874	203985	166182	172298	29322

TABLE IV. AUTOMATED ASSEMBLY LINE UPC ESTIMATE PER MACHINE OPERATION (CONCLUDED)

	Machine														
	AS1	AS2	AS3	AS4	AS5	AS6	I1	I2	I3	PP	PP	Wave Solder	Bench	PI	Pack
Manual Assembly	0.04	0.03	0.03	0.02	0.007	0.03	0.05	0.05	0.04	0.02	0.02	0.08	2.45	0.08	0.09
Part Fabrication															
Material	0.68	0.79	0.39	0.39	0.15	11.63							25.36		1.20
LBV	0.72	0.8[illegible]	0.42	0.41	0.16	11.66	0.05	0.05	0.04	0.02	0.02	0.08	27.81	0.08	1.29
Support	0.04	0.04	0.02	0.02	0.01	0.60				0.01			1.42	0.01	0.07
Factory Cost	0.76	0.86	0.44	0.43	0.17	12.26	0.05	0.05	0.04	0.03	0.02	0.08	29.24	0.09	1.36
G&A (19 Percent)	0.90	1.02	0.52	0.51	0.20	14.59	0.06	0.05	0.05	0.04	0.03	0.10	34.80	0.11	1.62
Machine Cost	45144	45144	60661	60661	54584	61016		782374				25000		82225	
Total Cost (With 19 Percent G&A)	53240	53840	72187	72187	64955	62609		931025				29750		97848	

10. AUTOMATED ASSEMBLY LINE INITIAL PRODUCTION FACILITY

A budgetary estimate was prepared for an initial production facility (IPF) for the automated assembly line. A detailed breakdown is shown in table V.

It should be noted that, in addition to the cost for a capability of 100, 000 units per month on a 1-8-5 production basis and 290, 000 units per month on a 3-8-7 production basis (same cost), there are projected costs for two pilot lines.

The one pilot line, one of each machine (station), would have a capability of 12, 000 units per month on a 1-8-5 production basis. The limiting item on this line is a test equipment station.

By procuring three additional test stations at each operation, pre-pot and post-pot, the capability could be increased to 50, 000 units per month. No other additional equipment would be required. The total cost for this additional capability is estimated at $462, 475.

During preliminary production planning sessions, additional data for the IPF andlow rate initial production programs were requested. These data are compiled in Appendix E and include machine costs, tooling costs, debug and acceptance hardware quantities, test equipment costs, and support and data item (documentation and manual) costs.

TABLE V. XM587E2/XM724 FUZE INITIAL PRODUCTION FACILITY MACHINE LINE

	S&A Module Assembly			Fuze			Totals		
	100,000 Units Per Month	Pilot (12,000 Units Per Month)	Pilot (30,000 Units Per Month)	100,000 Units Per Month	Pilot (12,000 Units Per Month)	Pilot (30,000 Units Per Month)	100,000 Units Per Month	Pilot (12,000 Units Per Month)	Pilot (30,000 Units Per Month)
Machines (Honeywell)	[illegible]	[illegible]	[illegible]	1441273	1138552	1138552	3018[illegible]	2335246	2335246
Machines (Other)	-	-	-	459073	353310	353370	459073	353310	353370
Test Equipment	-	-	-	782374	128687	375540	782374	128687	375540
Data Items	98424	98424	98424	98424	98424	98424	196848	196848	196848
Engineering Support									
Production Engineering	[illegible]	[illegible]	270666	328080	267500	270666	623332	535000	541[illegible]
Development Engineering	[illegible]	82000	82000	102000	96000	96000	192000	178000	178000
NC Engineering	[illegible]	[illegible]	15876	15876	15876	15876	31752	317[illegible]	317[illegible]
ID	[illegible]	8028	8028	8028	8028	8028	16056	16056	[illegible]
Quality Assurance Engineering	[illegible]	[illegible]	7401[illegible]	338245	295988	298606	[illegible]	370000	372[illegible]
Debug Hardware	[illegible]	[illegible]	47407	377008	308938	347410	731388	[illegible]	694817
Acceptance Hardware	[illegible]	[illegible]	178333	460543	338205	436770	[illegible]1472	586[illegible]	[illegible]9
Tooling									
Vendor Tools	[illegible]	[illegible]	[illegible]	209[illegible]	20[illegible]	2091[illegible]	[illegible]	[illegible]	[illegible]
Manufacturing Tools	[illegible]	[illegible]	[illegible]	498034	304537	304537	711[illegible]	[illegible]	[illegible]
Assembly and Material Handling	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	923[illegible]	[illegible]	[illegible]	[illegible]
Gages	[illegible]	[illegible]	[illegible]	513077	513077	513073	[illegible]	[illegible]	[illegible]
Total Cost	[illegible]	[illegible]	[illegible]	[illegible]	4325748	4655[illegible]	[illegible]	[illegible]	718[illegible]
Total Cost with 10 Percent G&A	[illegible]	[illegible]	[illegible]	7124037	5147540	[illegible]	10874[illegible]	812[illegible]	8[illegible]
Total Cost with 10 Percent Profit	[illegible]	[illegible]	[illegible]	7836441	[illegible]2404	[illegible]	[illegible]	[illegible]	[illegible]

Notes:

- Does not include [illegible] development [illegible]
- Assumes [illegible]

11. AMORTIZATION

Section 8 shows that the fuze built to the present technical data package will cost $93. 03 per unit for production of 100, 000 units per month. Section 9 shows that the fuze will cost $81. 07 per unit for production of 100, 000 units per month.

This is a savings of $11. 96 per fuze. This cost savings is accomplished against labor only. The same material costs were used in each analysis.

Section 10 shows a total cost of a balanced line for 100, 000 units per month of $11, 962, 396. At $11.96 savings per fuze, this cost would be amortized in 10 months.

Using the estimated costs generated for 100, 000 units per month, the projected cost of fuzes for 290, 000 units per month on a 3-8-7 production basis is $76. 16 for the manual assembly line and $67. 13 for the automated assembly line. At $9. 03 savings per fuze, the IPF cost would be amortized in 4. 6 months (see table VI).

The balanced line with a production capability of 100, 000 units per month on a 1-8-5 production basis, or 290, 000 units per month on a 3-8-7 production basis consists of 54 pieces of equipment.

Installation costs are estimated at $500. 00 per machine. Shipping costs are estimated at $28. 00 per hundred weight. The chart below shows the estimated weight by machine type:

Item	Average Weight (pounds) (each)
Honeywell-designed automated assembly machine	9500
Wave soldering equipment	2500
Punch out station	500
Spring winders	1800
Automated electronic component insertion equipment	
Axial-leaded component sequencer	3600
DIP inserter	1500

TABLE VI. MACHINE LINE UNIT PRODUCT COST ESTIMATE PROJECTED FOR 290,000 UNITS PER MONTH

Total Material	\$ 37.83	
Production Labor		
Production Burden		
Inspection Labor	\$ 5.73	
Inspection Burden		
Subtotal		\$43.56
Shrink/Surplus at 0.9 percent	\$ 0.39	
Quality Assurance Engineering Labor	\$ 0.05	
Quality Assurance Engineering Burden	\$ 0.05	
Production Engineering Labor	\$ 0.10	
Production Engineering Burden	\$ 0.09	
Production Engineering Labor	\$ 0.08	
Production Engineering Burden	\$ 0.08	
Lot Sample Test	\$ 0.55	
Factory Cost		\$44.95
G&A (19 percent)	\$ 8.54	
Total Cost		\$53.49
Profit (15 percent)		
Total Price		\$61.51
Power Supply	\$ 5.50	
Data	\$ 0.06	
Total Cost		\$67.13

Item	Average Weight (pounds) (each)
Axial-leaded component inserter	1500
Crimp station	5000
Encapsulation	
Pre-heat oven	12000
Curing oven	15000
Dispenser	2500

The annual maintenance cost for the balanced automated line is estimated at $143, 784.

The cost to pack and preserve for 10 years $52, 399.

Additional facilities costs such as lay-a-way, relocation to the production floor, and site preparation are shown in table VII.

TABLE VII. ADDITIONAL FACILITIES COSTS

	Number of Machines	Total Hours	Maintenance Rate	Total Cost, S&A Module Assembly	Total Cost, Fuze	Total Cost
Lay-A-Way	54	3672	$14.27 per hour	12615	39784	52399
Maintenance Cost						
Annual Maintenance Cost	54		$1200 per machine per year	15600	49200	64800
Tool Maintenance	54		$1462.67 per machine per year	18956	60028	78984
Relocation Cost						
Move	54	8 per machine		1484	4681	6165
Install	54	24 per machine		5101	16093	21194
Shipping Cost to Other Destination						$28 (per hundredweight)
Total Cost						223542
Total Cost (with 19 Percent G&A)						266015
Total Cost (with 10 Percent Fee)						292617
Cost of Money (0.2 Percent)						447
Total Price						293064
Facility						900000

APPENDIX A

DIAL-INDEX AUTOMATED ASSEMBLY MACHINE STANDARDIZATION

Honeywell has designed, fabricated, and used in production over 1100 automated assembly machines. In the course of this accomplishment, the designs of all major components of these machines have been standardized. This standardization and past experience will be applied to the XM587E2/XM724 fuze automated assembly line and its associated S&A module automated assembly line. The following major machine components are described in detail:

- OML-189 machine base.
- Horizontal transfer mechanism.
- Swinging transfer mechanism.
- Magazine stacker.
- Spring magazine dispenser.
- Drop staker.
- Probes.
- Blank and feed tape.
- Detonator feed.
- Electronic machine control system.

OML-189 MACHINE BASE

The OML-189 dial-index machine base (figure A-1) is designed for minimum maintenance and maximum life. The frame is constructed of stress-relieved castings to preclude any possibility of dimensional change or warpage throughout the life of the machine. Work stations are operated by the vertical reciprocating action of the cam-driven upper tooling plate and by a horizontal cam shaft mounted beneath the tooling platform on the machine base. It has ample space and mounting areas above or below the indexing dial. Parts feeding hoppers and other tooling equipment may be placed at convenient positions at the full circumference of the dial. The machine base occupies a floor space of 5 square feet and is 7 feet high. The 7-foot height includes the electronic control cabinet mounted above the machine base. The indexing dial drive mechanism is provided with a mechanical overload breakaway system which prevents damage to machine components in the event of a jammed dial.

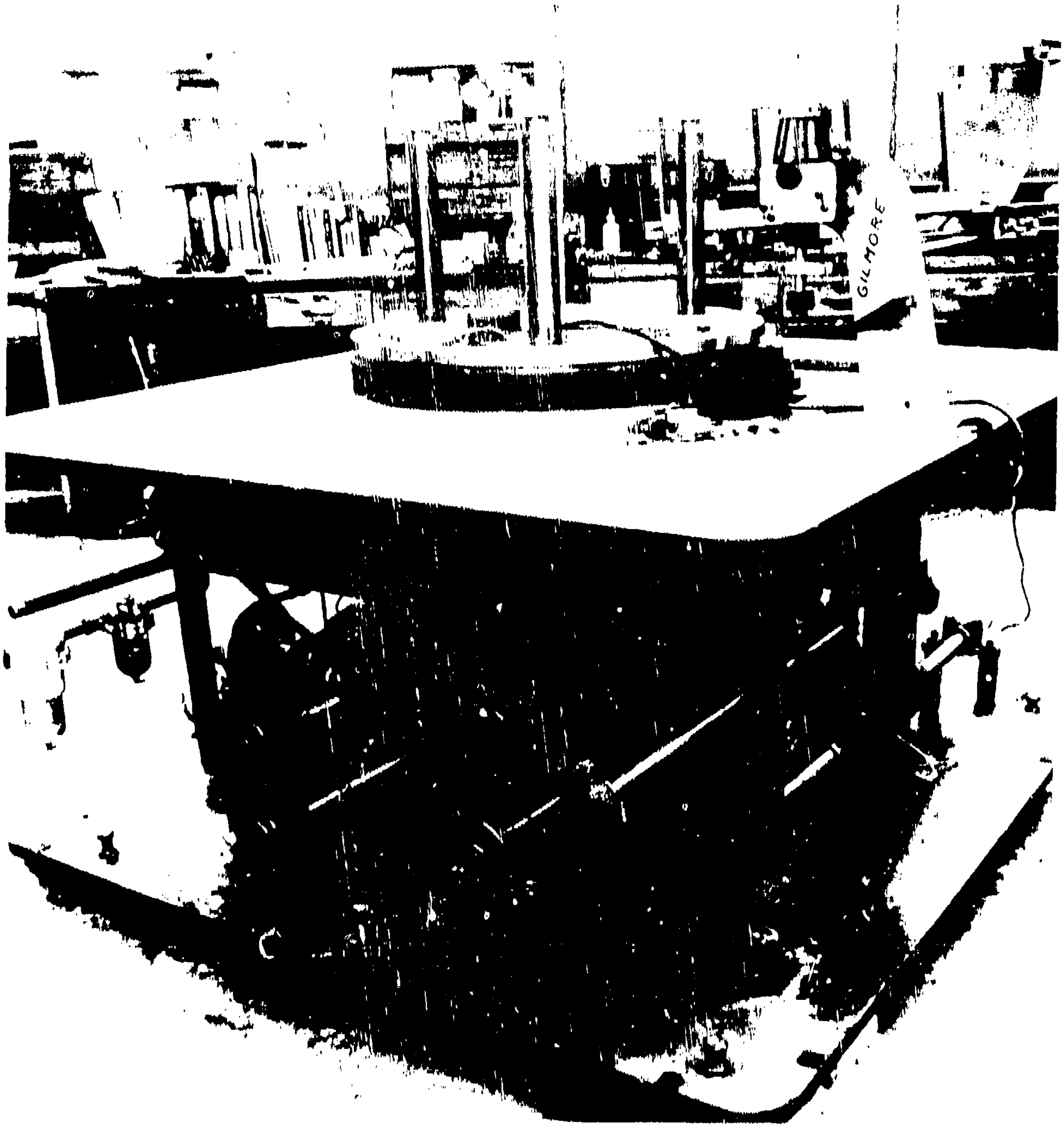


Figure A-1. OML-189 dial-index machine base

Should a breakaway occur, the dial stops, and, simultaneously, an electric circuit is broken to disengage the drive motor and apply a brake to the machine mechanism. To ensure functioning of the air springs, clutch, brake, and other pneumatic components of the machine, a minimum preset level of air pressure is required. A drop in air pressure below this level will actuate a switch that stops the machine.

A single lever type lubricator provides instant lubrication to all internal and hidden bearings of the machine to ensure protection of all wear surfaces. All machine cam arms, levers, and bearings are furnished with grease fittings or oil cups for periodic lubrication.

Tooling plate rigidity and positional accuracy are attained by three vertical columns actuated by a central toggle system. The tooling plate movement is produced by a closed cam which assures positive timing accuracy with other functions of the machine base. Indexing accuracy of the next transportation dial is achieved by using a shot pin that enters a hardened bushing in the dial adjacent to each of the nests.

HORIZONTAL TRANSFER MECHANISM

The horizontal transfer mechanism (figure A-2) is made in three size ranges which cover most applications. Actuation is achieved by a cam, linkages, and a bell crank which drive a sliding block along two horizontal hardened shafts confined in a bridge frame mounted on a riser and steel base. Adjustable stops are provided at each end of the shafts to limit the forward or backward motion.

The sliding block carries a vertical plunger, either hollow or solid, supported in bronze bearings. Vertical reciprocating action is supplied to the plunger by the single drive cam through a teeter bar and linkages. Various types of pickup heads can be mounted on the lower end of the plunger for holding the item to be delivered to the dial nest.

SWINGING TRANSFER MECHANISM

Honeywell's standard swinging transfer mechanism (figure A-3) is made in two sizes to accommodate various parts. These transfer mechanisms are designed to pick up parts that are presented to the mechanism at a 25- to 30-degree angle. The delivery position of the mechanism is a 90-degree vertical position directly over the placement area.

The swinging transfer mechanism is suspended in roller bearings between the upright mounting plate and the outboard bearing plate. The

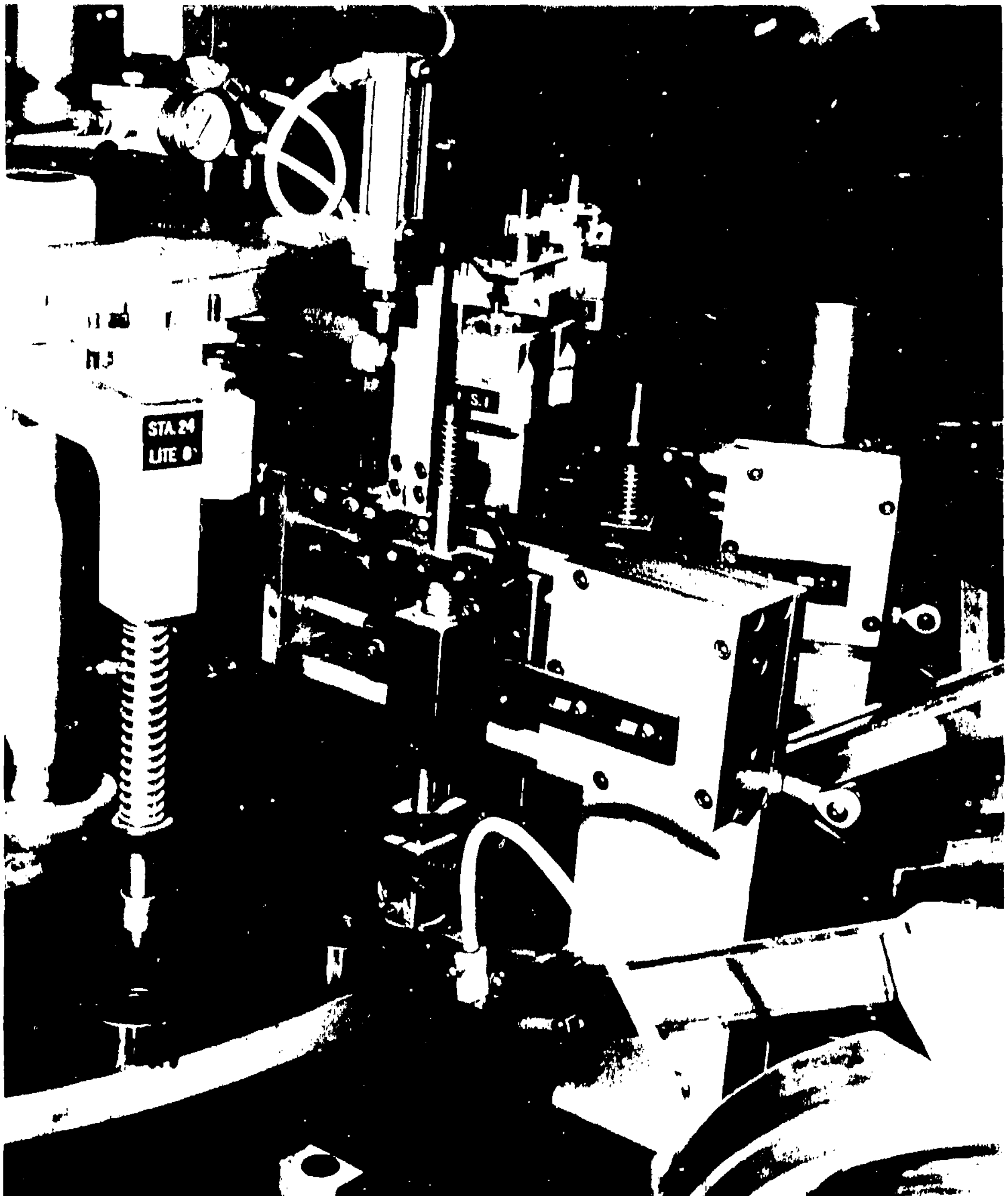


Figure A-2. Horizontal transfer mechanism

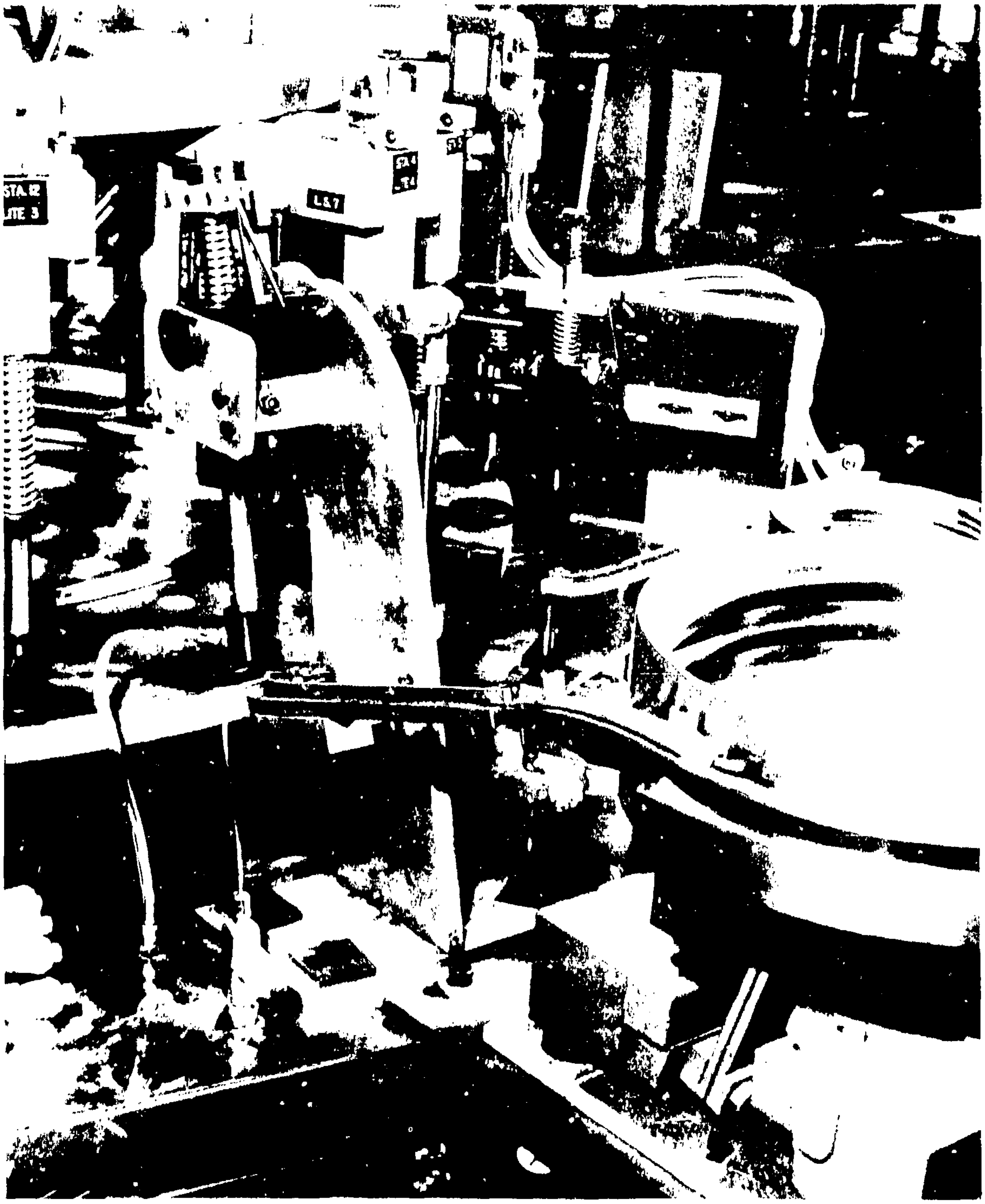


Figure A-3. Swinging transfer mechanism

upright mounting plate supports the part track or other required tooling and is attached to a wide base plate and gusset for rigidity and mounting purposes. The swinging transfer arc and the up and down motions are obtained with a single cam, a lever arm, and linkages.

The pickup head that engages and holds the part is custom designed to fit the configuration of the part. The head is fastened to the shaft of the transfer mechanism and is easily removed for repair or servicing.

MAGAZINE STACKER

The standard Honeywell magazine stacker (figure A-4) has been developed as a means of feeding and ejecting subassemblies where methods of bulk feeding are inadequate. The magazine handling mechanisms for either feeding or ejecting subassemblies are identical. In most applications, the feeding stacker is mounted at an inclined angle and the eject stacker is mounted horizontally. The inclined feeding stacker includes a section of track at the output end of the magazine and a photocell detector which monitors the supply of subassemblies and initiates an air cylinder or lateral ejection of the empty magazine. The horizontal eject stacker includes a section of track at the input end of the stacker and a micro switch at the opposite end which initiates the air cylinder for lateral ejection of the filled magazine. The air cylinder is connected to linkages and two bell crank arms that provide ejection and also control the drop rate of the next magazine on the return stroke. An enclosed area to the vertical stack retains the ejected magazines.

SPRING MAGAZINE DISPENSER

Spring magazine dispensers (see figure A-5) are designed to accommodate various sizes of magazines, depending upon the diameter and length of springs. The smaller spring magazines are placed into the dispenser in a vertical stack and the larger magazines are placed in a horizontal row, side by side. The smaller magazines include a row of equally spaced holes to receive the springs and a smaller lower hole to index the magazine. For large springs, the magazines contain vertical pins to receive the springs and a lower hole for indexing. The magazines are incrementally advanced by a square motion mechanism driven by a cam on the machine, or pneumatically, with each cycle of the machine. On the vertical dispenser, the bottom magazine is advanced through a shroud, and a timed air jet from below the magazine transfers the spring through a tube to a delivery head or into the assembly. The larger magazines are advanced in a

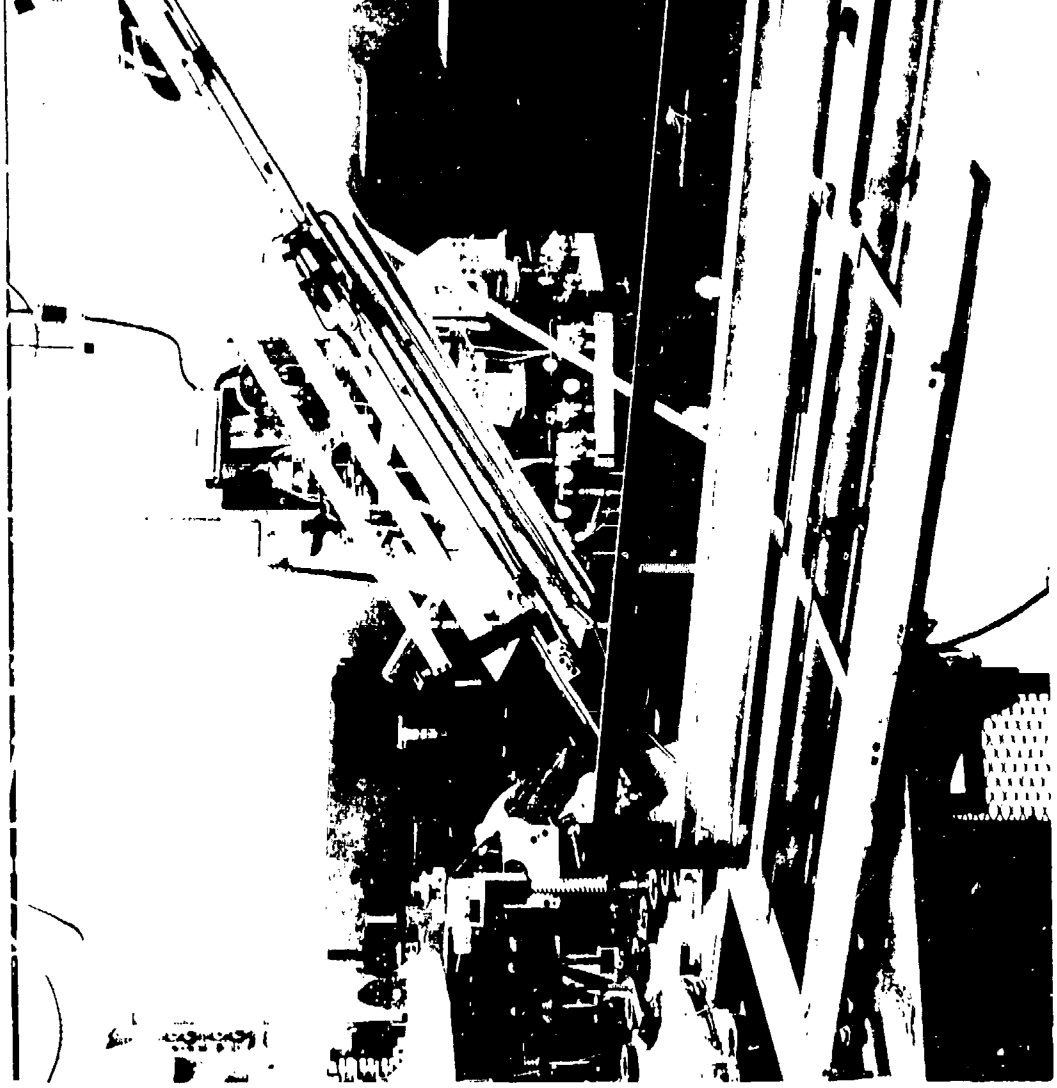


Figure A-4. Magazine stacker

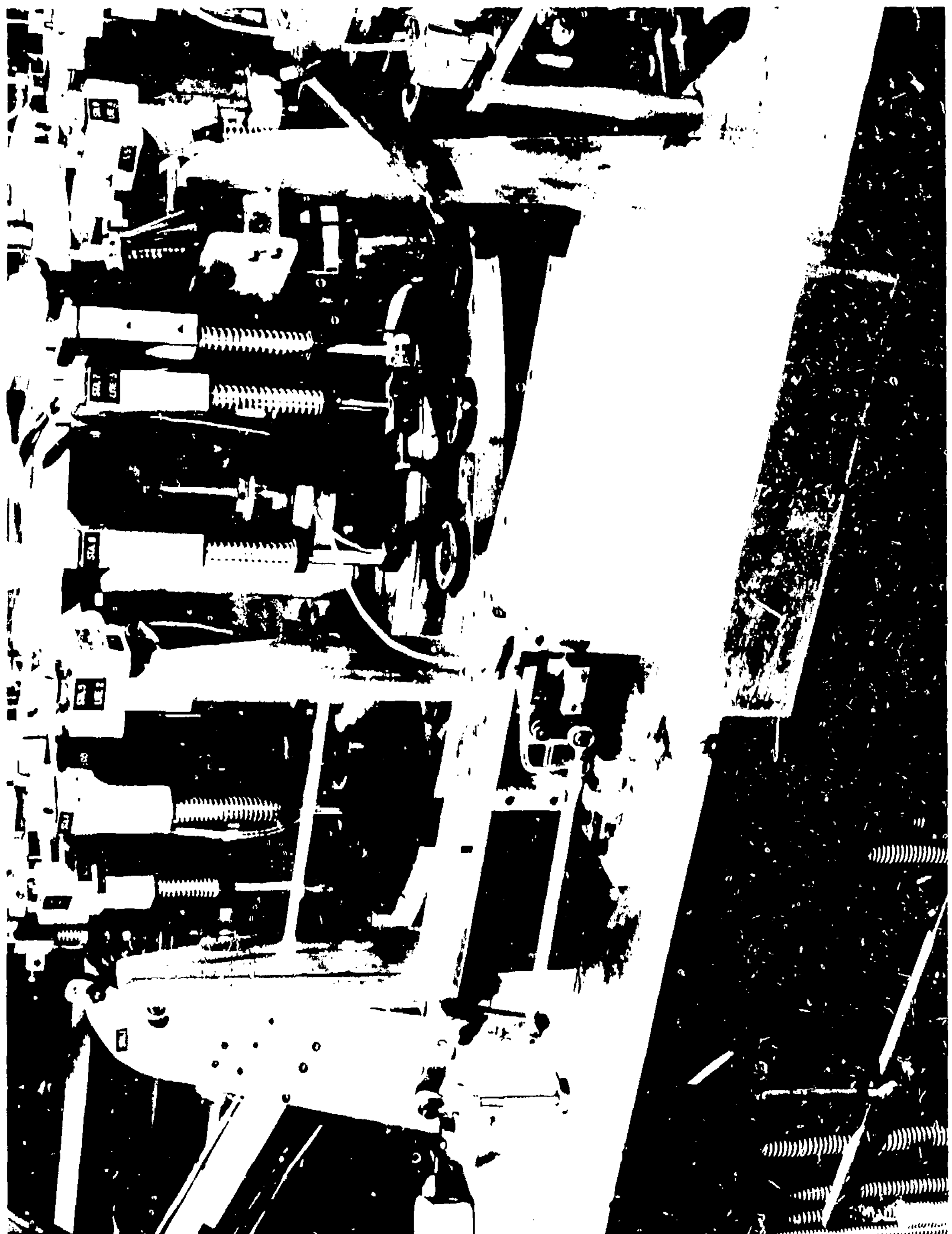


Figure A-5. Spring magazine dispenser

similar manner, except the first magazine in the row is advanced at a right angle direction into position for delivery. The vertically stacked magazines are allowed to gravity fall into the index position. The larger horizontal magazines are pneumatically powered into the index position. Magazines may be changed in either case without stopping the automated assembly machine or spring coiler.

DROP STAKER

The drop staker (figure A-6) is used in applications that require light staking operations. A spring-loaded plunger and impact unit is mounted on the upper tooling plate above the subassembly to be staked. The downward action of the upper tooling plate lowers a replaceable staking tool into preloaded contact with the subassembly. The impacting weight, cocked at the previous retraction of the tooling plate, is triggered to drop when the preload on the staking tool approaches its maximum pressure.

PROBES

Piece Part Presence and Position

All of the standard probes used in conjunction with standard Honeywell dial-index automated assembly machines with an upper tooling plate are constructed from the same basic design. Figure A-7 shows standard probes. A rugged casting containing oilite bushings is mounted on the upper tooling plate above the part or subassembly to be checked. The casting carries a set of microswitches, a steel plate with adjustment screws, a spring and collar, and a 5/8-inch-diameter stainless steel shaft. A probing shoe designed to stop or enter the desired features of the part or subassembly is mounted at the lower end of the shaft. If the desired feature is missing or out of position, one of the two microswitches will be actuated, causing the machine to stop, or a memory to be established. The defective unit will be rejected at the reject position.

Part Reference

The part reference probe is similar in appearance to the standard presence and position probe except that it includes two precision microswitches and an internal sliding shaft. Probing shoes designed to meet the specific application are mounted on the lower end of the two shafts. The outer shoe contacts the area of the part that is the required reference surface, and the inner shoe checks the desired feature of the part. Any variation from the set point is detected by one of the microswitches, which then establishes an accept or reject signal to the memory circuit or stops the machine.

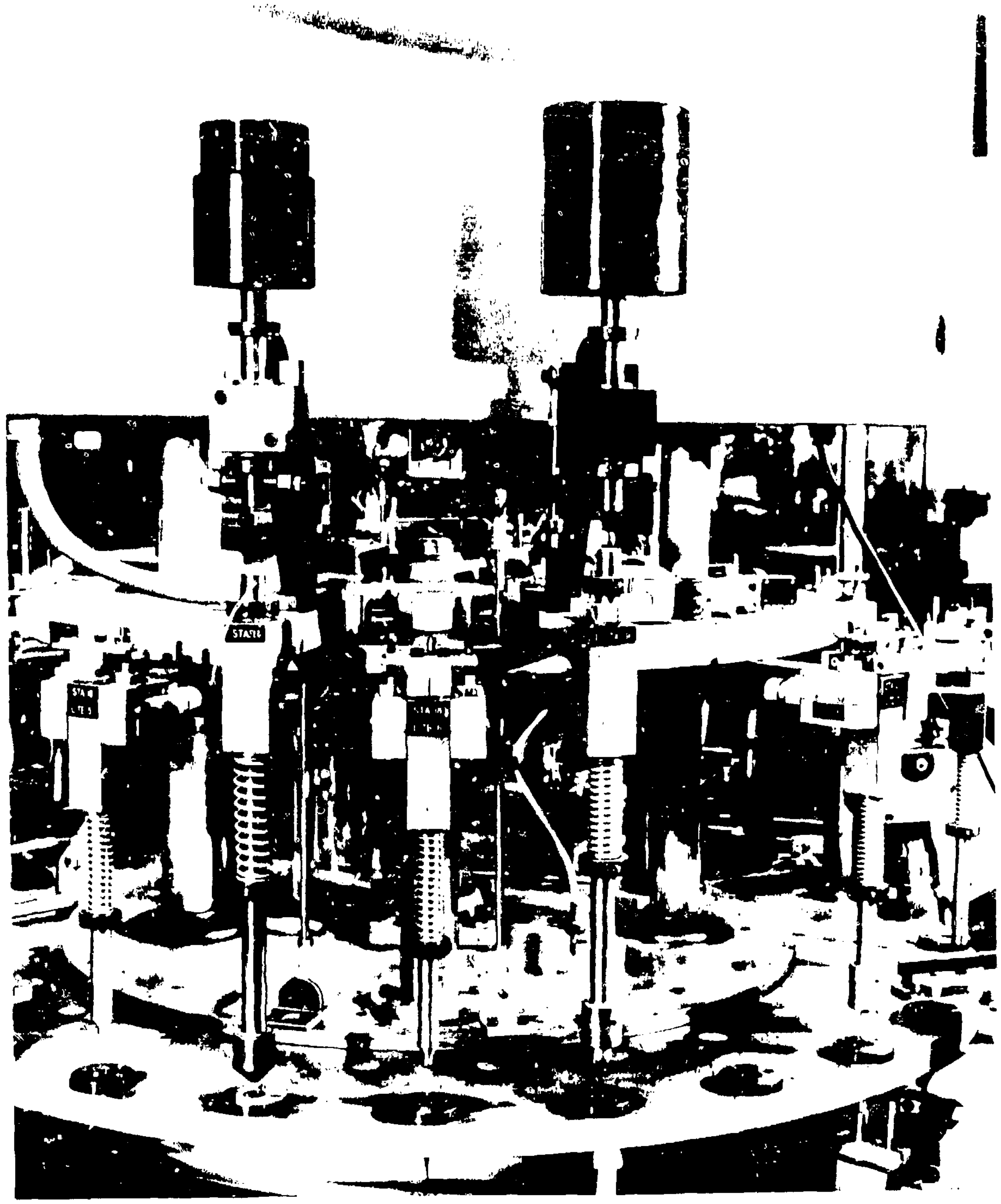


Figure A-6. Drop staker

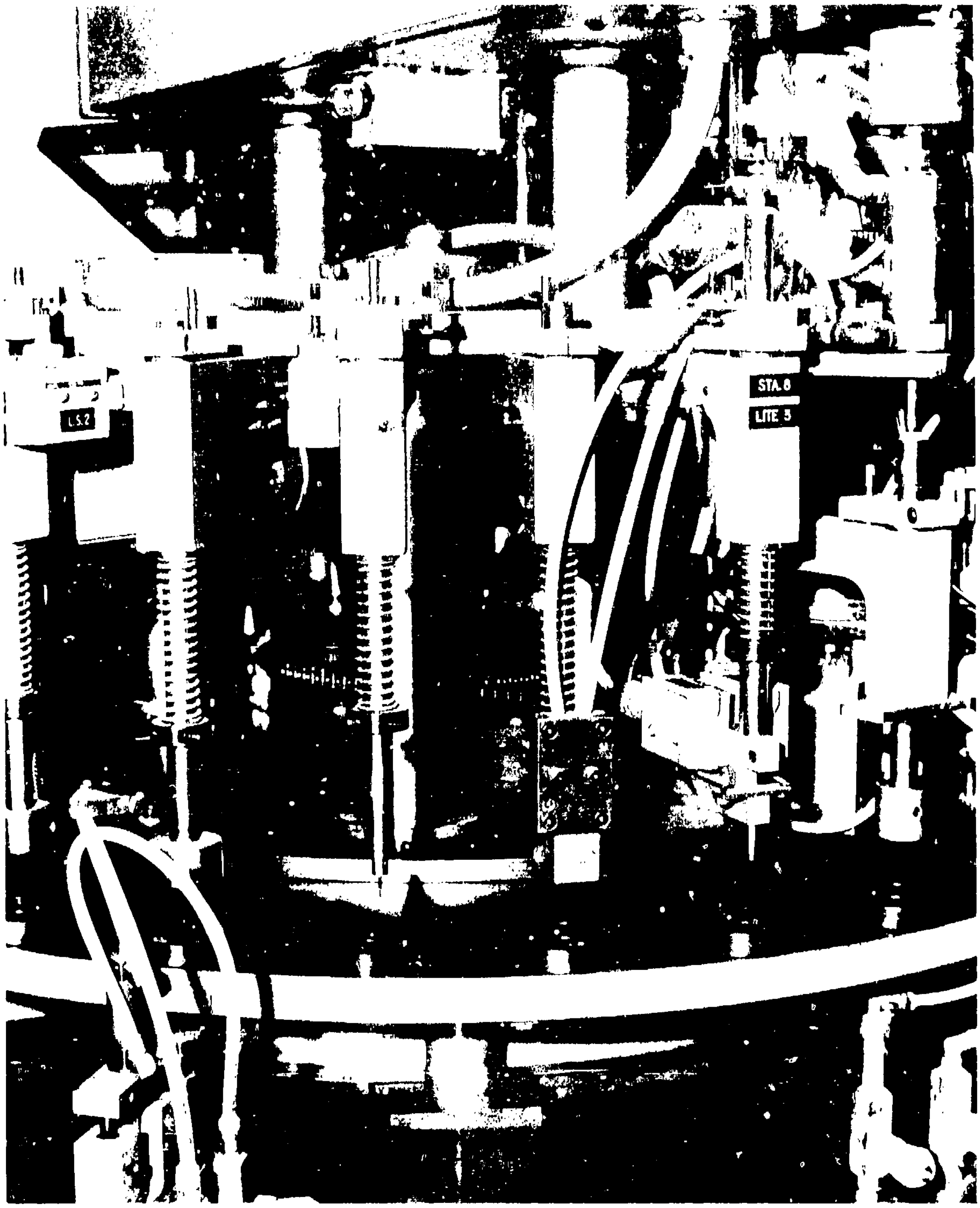


Figure A-7. Probes

FEED AND BLANK TAPE

The standard tape feeding and blanking tools (figure A-8) are self-contained units mounted on the lower tooling plate and extending over the dial nest. The tape material is supplied to the unit in coil form and advanced by feeding rolls to a punch and die assembly mounted on the extended frame directly above the dial nest. The punch is actuated pneumatically to blank and carry the tape through the die to the subassembly.

The coil stock is automatically advanced by chain-coupled feed rolls, driven by a single direction overrunning clutch, which is reciprocated by a lever from the base cam shaft. The extended frame supports a second reel on which the skeleton scrap is rerolled. Vacuum is applied through a centrally located hole in the punch to retain the blanked tape on the punch until the tape is placed on the subassembly. At that time, the vacuum is shut off and a slight positive pressure is applied through the hole in the punch to release the tape.

DETONATOR FEED

Detonators which have been previously preloaded into magazines are supplied to the feeder platform in trays containing 20 magazines. A pusher bar and gravity feeding mechanism moves the magazines into position for incremental advancement. The magazines are incrementally advanced by a square motion slide, driven by a cam or pneumatically, into position directly over a plunger. The plunger lifts the detonator from the magazine and inserts it into a spring collet or vacuum head contained in a horizontal transfer arm. The transfer arm is driven through linkage by a cam on the lower cam shaft of the machine base. When a stripping plunger is used on the upper tooling plate, the plunger strips the detonator from the collet into the subassembly and will also act as a probe to determine the presence and proper seating of the detonator. When a vacuum head is used, vacuum retains the detonator during transfer, and a slight positive pressure is applied to release the detonator as it is inserted. The entire unit is enclosed by acrylic plastic shields with an open top and interlock doors for safety considerations. Figure A-9 shows a detonator feeder.

ELECTRONIC MACHINE CONTROL SYSTEM

Honeywell's electronic machine control system consists of five main parts -- a shaft encoder, sensing elements, decisions elements, memory elements, and work elements.

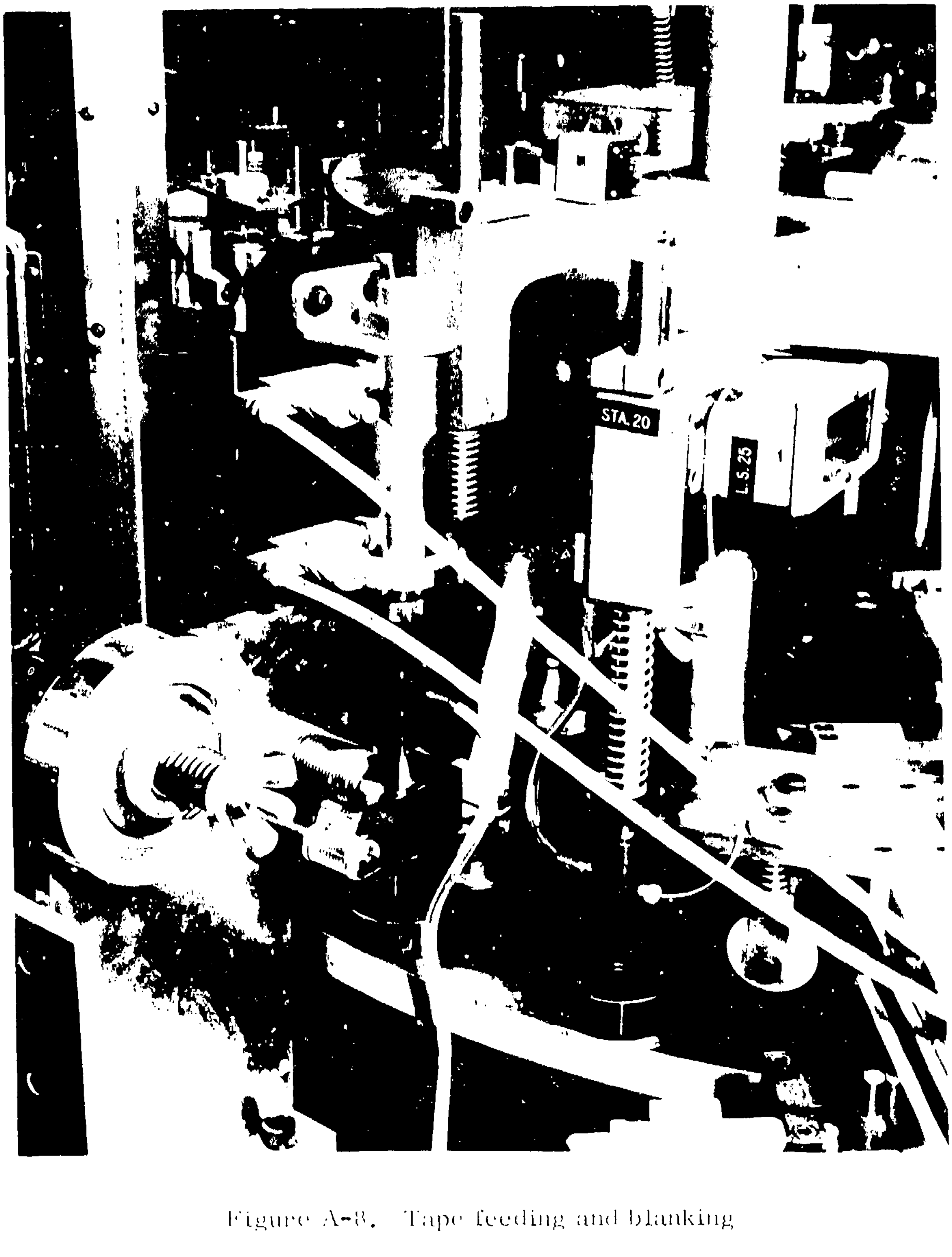


Figure A-8. Tape feeding and blanking

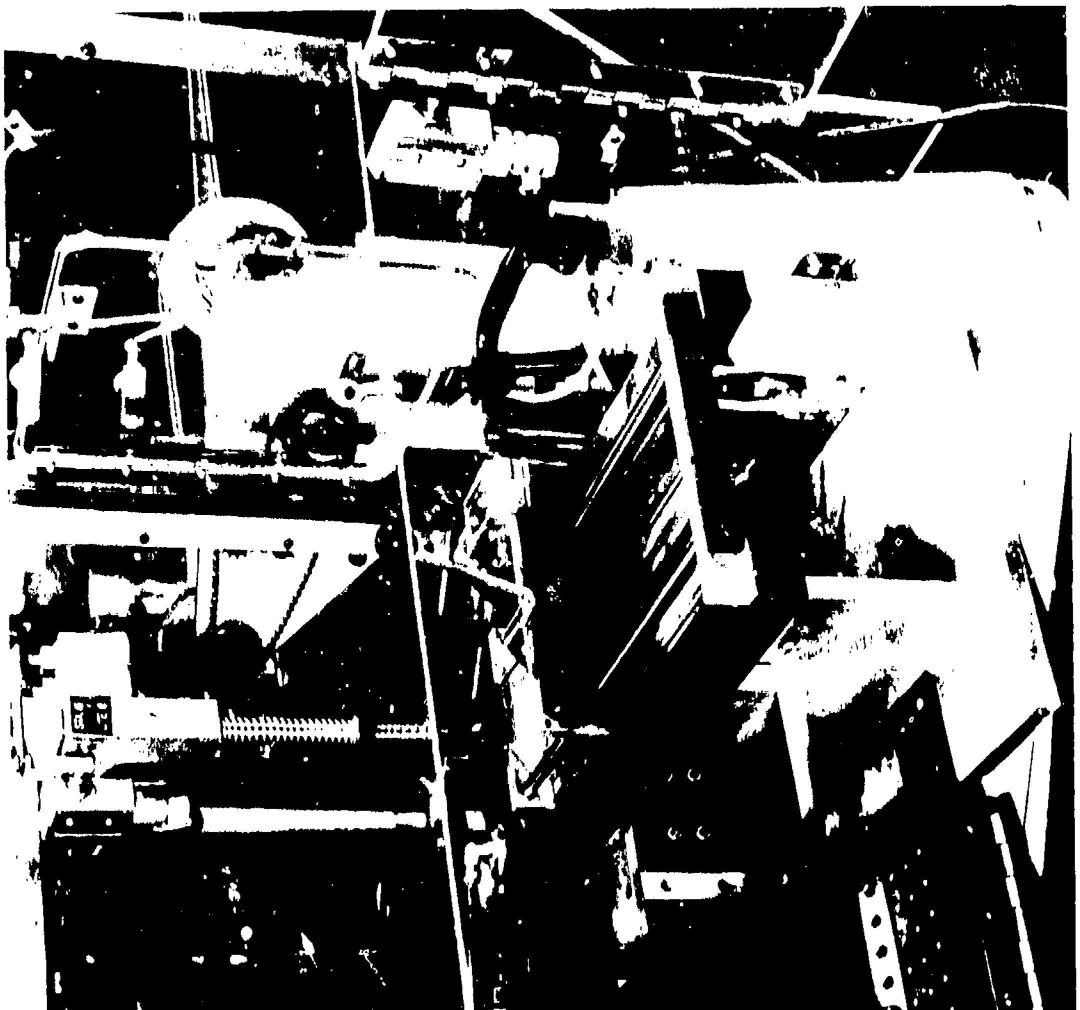


Figure A-9. Detonator feeder

Shaft Encoder

The shaft encoder is a device used to sense the radial position of the mechanical control shaft. Both the mechanical control shaft and encoder make one complete revolution with each index cycle of the machine. In one revolution, the shaft encoder has a capability of 120 command pulses in 3-degree increments.

The pulses are used to command the machine control elements to function and do their work at preset mechanical positions during the index cycle.

Sensing Elements

The sensing elements consist of limit switches, pressure switches, photodiodes, temperature sensors, transducers, time interval meters, or any information-collecting device that will provide information to the decision elements.

Decision Elements and Memory Elements

Each dial-index automated assembly machine described in this document will be equipped with a new microcomputer processor. This new innovation represents the latest approach to complete machine control and process monitoring.

The new processor is approximately one-third the size of the conventional solid-state controller. It presents a new dimension to station control and process monitoring because it offers programming flexibility during initial machine control setup, and, later, if changes are deemed necessary, the processor can be reprogrammed.

The system has a 4000-word, 1 to 4-bit memory and provides a digital display to identify stations that are detecting malfunction. The use of the microcomputer permits similar wiring for each machine. Variations between machines are easily accommodated by a change in programming. The new processor enables any station to be locked out on command.. It can be used to sort parts or subassemblies by maintaining appropriate memory.

Each machine will have counter variables for machine stoppages which will permit a station to run from one to five times with identified rejects. This provides an opportunity for the machine to correct itself before stopping. Rejected piece parts or subassemblies that continue through the station(s) are retained in the memory and later rejected from the machine.

On command, the efficiency (number of good parts versus total) will be displayed as a percentage for individual stations or for the entire machine. The machine can be programmed to stop if the percentage exceeds predetermined limits.

Honeywell has successfully employed the new microcomputer processor on the Rockeye II weapon system production program. Performance of the system has been outstanding. This excellent experience has convinced us to incorporate the system on future Honeywell-designed and built automated assembly machines.

Work Elements

The work elements consist of solenoids, motor starters, air valves, motors, hopper feeders, and other devices which are needed to initiate and accomplish the actual working operations. The work elements receive information from both decision elements and the memory elements and, upon command of the shaft encoder, do the work as directed by the information received.

All electrical components used in this installation comply with the National Electrical Code (NEC).

The electronic machine control system provides low cost maintenance, high reliability, long machine life, and a high degree of flexibility.

APPENDIX B

XM587E2/XM724 FUZE BASIC PRODUCTION FACILITY RAM PREDICTION/ALLOCATION BY AUTOMATED ASSEMBLY MACHINE

INTRODUCTION

Presented herein is a preliminary prediction of the reliability/availability/maintainability (RAM) characteristics of the automated assembly machines and test equipment as presently conceived for the XM587E2/XM724 fuze basic production facility.

PURPOSE

This preliminary RAM prediction/allocation is intended to fulfil two purposes:

- To help establish reasonable RAM values, particularly machine availabilities, for use in system analysis and planning of the proposed basic production facility.

- To help determine early in the automated assembly line design process any potential machine availability problem areas.

SCOPE

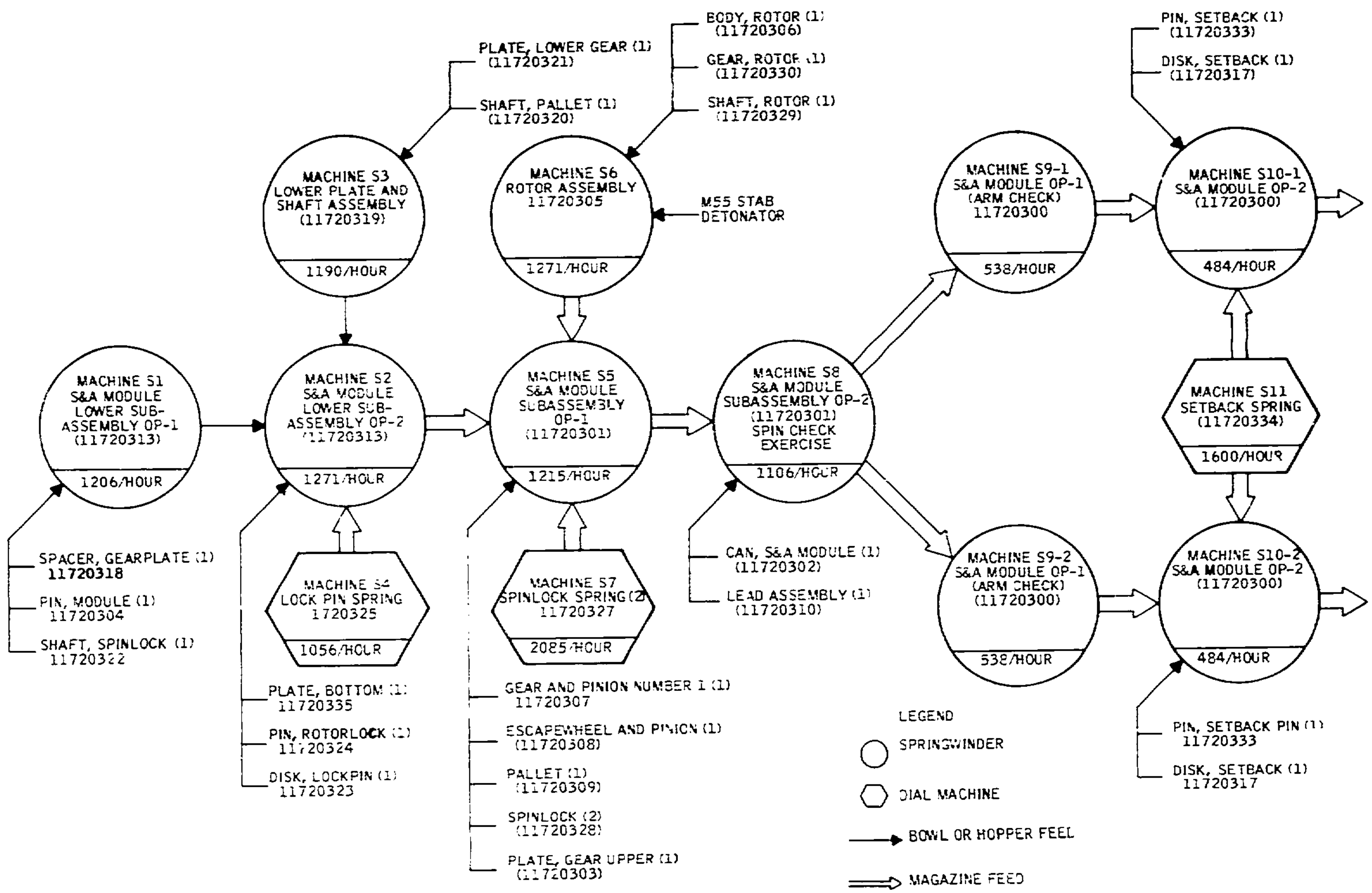
The machine concepts analyzed in this report include the following (see also the process flow diagrams of figures B-1, B-2, B-3):

- S&A module assembly machines S1, S2, S3, S5, S6, S8, S9, and S10.

- Fuze automated assembly line (part A) machines AS1 through AS6, E1, E2, T1, and the wave soldering machine.

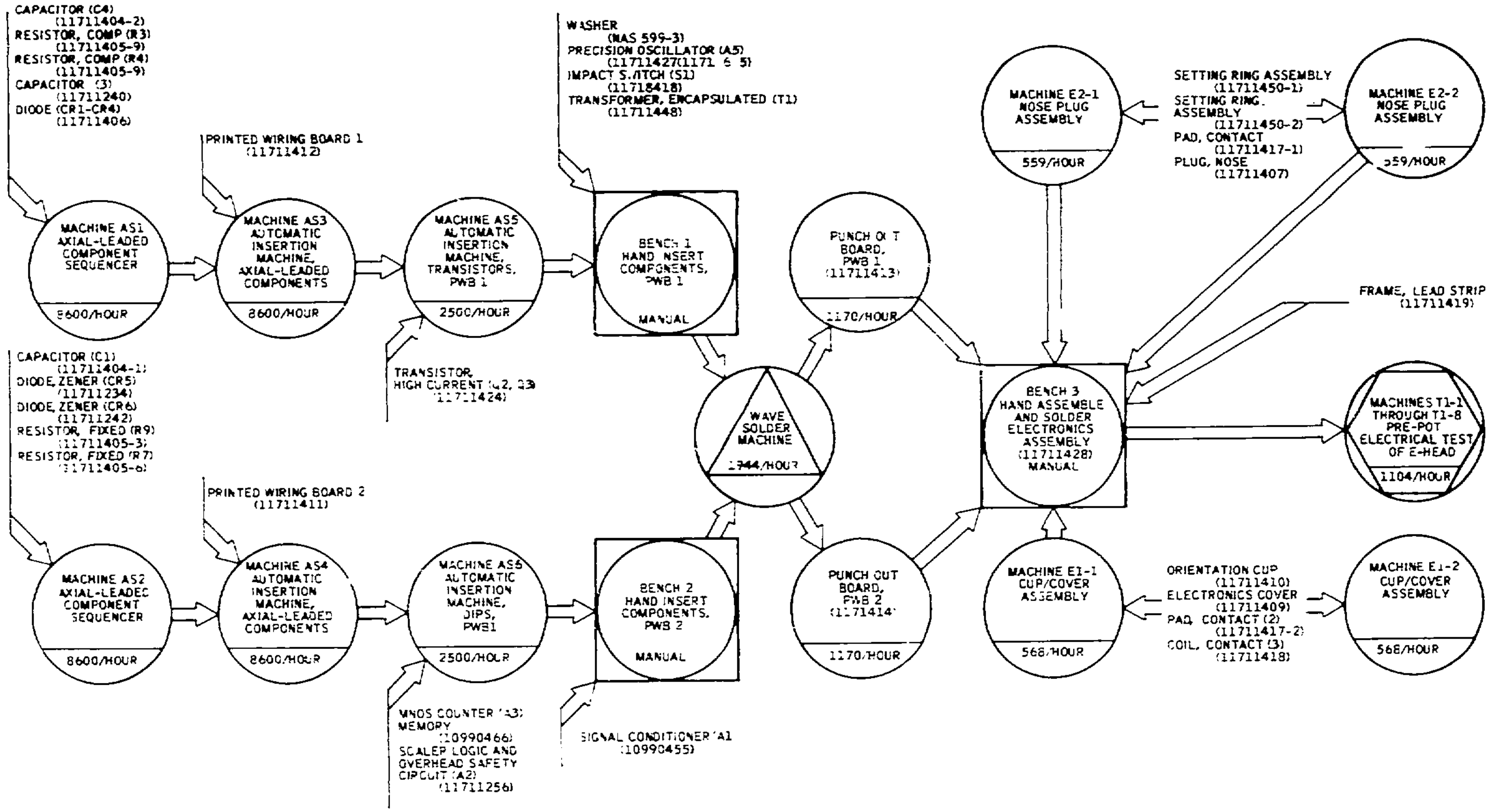
- Fuze automated assembly line (part B) machines F1 through T2, T3, and the potting machine.

The S, E, and F machines listed above are expected to be of the Honeywell dial-indexing type or equivalent. The AS1 through AS6



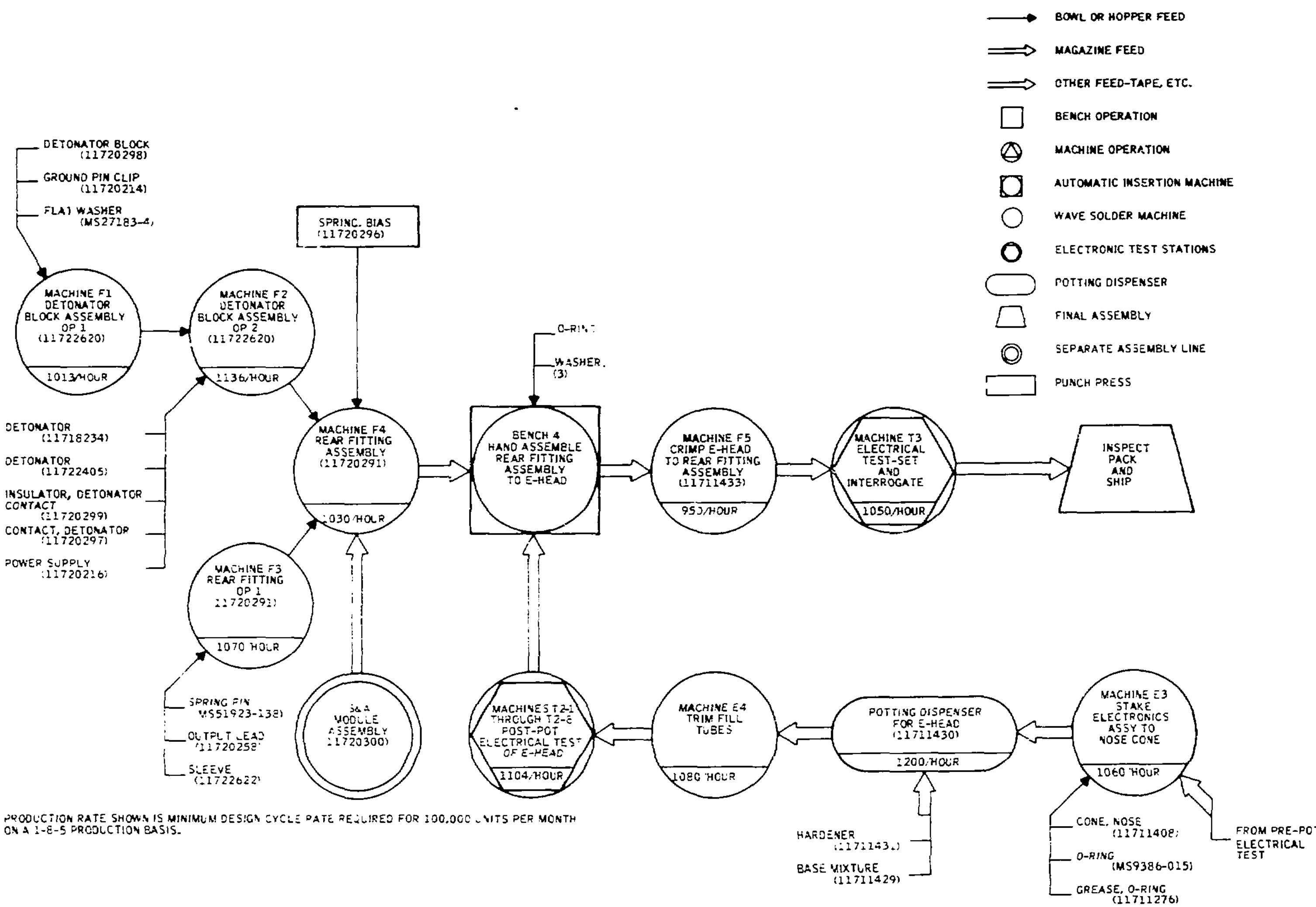
NOTE: PRODUCTION RATE SHOWN IS MINIMUM DESIGN CYCLE RATE REQUIRED FOR 100,000 UNITS PER MONTH ON A 1-8-5 PRODUCTION BASIS.

Figure B-1. XM587E2/XM724 fuze S&A module automated assembly line process flow diagram and production rate



NOTE: PRODUCTION RATE SHOWN IS MINIMUM DESIGN CYCLE RATE REQUIRED FOR 100,000 UNITS PER MONTH ON A 1-8-5 PRODUCTION BASIS.

Figure B-2. XM587E2/XM724 fuze automated assembly line part A process flow diagram and production rate



NOTE: PRODUCTION RATE SHOWN IS MINIMUM DESIGN CYCLE RATE REQUIRED FOR 100,000 UNITS PER MONTH ON A 1-8-5 PRODUCTION BASIS.

Figure B-3. XM587E2/XM724 fuze automated assembly line part B process flow diagram and production rate

machines are electronic component sequencing and insertion machines such as are available from Universal Instruments and possibly other manufacturers. The T1-T3 items are test stations.

Spring winders, such as machines S4, S7, and S11, are auxiliary equipment that generally have much higher rates than the machines they support and are not considered a significant factor in this analysis. They are generally relatively trouble-free machines.

CONCLUSIONS AND RECOMMENDATIONS

This preliminary prediction indicates a range of assembly machine availabilities from 75 percent for a complex dial-indexing automated assembly machine to 98 percent for an electronic component sequencer, based on the limited user data currently available. Machine S2 is the only dial-indexing machine with a category five station (most complex or troublesome category), which is assigned a 10 percent lower station availability than a category four station. An effort should be made to reduce category numbers through design improvements and simplification wherever practical.

The actual impact of the availability of any machine must consider other factors such as operation efficiency, production rates, storage of parts, and cost tradeoffs. It is recommended that a system analysis be performed on the proposed automated assembly line in light of these preliminary RAM results and other factors affecting output and efficiency of the entire line.

SUMMARY OF PREDICTED MACHINE AVAILABILITIES

The values shown on the following page are the predicted machine availabilities expected to be achievable in an established high-volume automated assembly line with appropriately trained operating and maintenance personnel available.

In arriving at these values, it was assumed that machine failure is a stoppage that required skilled repair or maintenance personnel to remedy.

DISCUSSION

Accurately predicting RAM characteristics for machines is very difficult because of a general lack of published RAM data on machines in use and the variety of machine operations performed.

Machine	Availability (Percent)	Machine	Availability (Percent)	Machine	Availability (Percent)
S1	83	AS4	95	T1	989
S2	77	AS5	95	T2	988
S3	85	AS6	90	T3	989
S5	78	E1	81	Wave Soldering Machine	95
S6	79	E2	83	Potting Machine	92
S8	76	E3	84		
S9	77	E4	75		
S10	82	F1	91		
AS1	98	F2	79		
AS2	98	F3	84		
AS3	95	F4	84		
		F5	90		

The data base used in this analysis included information from two basic sources:

- Data on dial-index automated assembly machines were obtained from a group of Honeywell manufactured machines in use at the Twin Cities Army Ammunition Plant, New Brighton, Minnesota. These machines had been producing M223 mechanical fuzes at high rates for at least six months when data collection was started in late 1975 by the Honeywell RAM committee.

- Data on other assembly and test equipment were obtained by telephone from machine manufacturers and from various Honeywell (and other) facilities across the country that have been using similar equipment.

Dial-Indexing Automated Assembly Machines

In collecting the data from Honeywell dial-indexing automated assembly machines, only those stoppages that required repair maintenance personnel were recorded; short stoppages such as those that could be quickly corrected by the operator were not recorded (the latter type is to be allowed for elsewhere in calculating automated assembly line output rates).

The mean time between failures (MTBF) characteristic on the M223 fuze machines was determined from the relationship MTBF = T_o/N_f, where T_o was the total operating time in the period specified on machine log sheets and N_f was the total number of machine failures occurring in that period.

Total operating hours were determined from machine counter readings and the machine cycle rate.

The mean time to repair (MTTR) characteristic was determined from the relationship MTTR = T_R/N_f, where T_R is the summation of times required to repair the N_f, machine failures.

Machine availability was then calculated from the relationship A = MTBF/(MTBF + MTTR).

The data from the M223 fuze machines were further broken down for prediction purposes to reflect differences between types (or sizes) of machine bases and differences between types of machine stations. Table B-I summarizes RAM values relative to Honeywell OML-189 machine bases (24-30 stations) and OML-315 machine bases (21 or fewer stations) and the combined results. Table B-II summarizes RAM values for various categories of machine stations, from simple to complex. The five categories are defined in a general manner as follows:

- Category 1 - A simple probe station such as a work station that verifies the presence and position of a part or assembly in the holding nest, or probes to verify an empty nest.

- Category 2 - A slightly more complex station such as a work station that ejects or rejects assemblies or probes for presence of explosive parts.

- Category 3 - A more complex station such as a feed station, a pull or press station, or a probe to a specific dimension.

TABLE B-I. RAM DATA SUMMARY, AUTOMATED ASSEMBLY MACHINE BASES

Base Type	Total Operating Hours	Failures	MTBF (Hours)	Total Repair Hours	MTTR (Hours)	Availability (Percent)
OML-189 Base	172.0	2	86.0	3.0	1.5	98.29
OML-315 Base	830.1	10	83.01	12.74	1.27	98.49
All Bases	1002.1	12	83.5	15.74	1.31	98.45

TABLE B-II. RAM DATA SUMMARY, WORK STATIONS

Category/Type	Total Operating Hours	Failures	MTBF (Hours)	Total Repair Hours	MTTR (Hours)	Availability (Percent)
Category 1	4716.7	2	2358.35	2.25	1.13	99.95
Category 2	4438.7	3	1479.57	1.96	0.65	99.94
Category 3	5986.9	67	89.36	79.23	1.18	98.70
Category 4	2667.7	60	44.46	97.58	1.63	96.46
Category 5	382.5	25	15.3	58.16	2.33	86.78

Note: RAM values are applicable to individual work stations of the category listed.

- Category 4 - A more complex station that performs an assembly/manufacturing operation or a test such as staking a detonator, pushing and probing to a dimension, adjusting a screw or feeding a difficult part.

- Category 5 - A complex or troublesome station usually performing multiple functions such as the feed and installation of a screw to a certain dimension or force.

Each of the functional stations on the planned XM587E2/XM724 fuze dial-index automated assembly machines was assigned a category number based on the preceding category descriptions and engineering judgment based on input from machine design personnel familiar with the specific parts and anticipated station design characteristics for this application. Figures B-4 through B-19 show the currently planned machine dial schematics with assigned station categories.

Table B-III indicates the calculated MTBF, MTTR, and availability values for the various XM587E2/XM724 fuze dial-indexing automated assembly machines as currently conceived. Note that no dial schematic is available for machine F5, which will crimp the electronics and nose cone assembly (E-head) into the rear fitting assembly. This machine will be purchased commercially and essentially consists of a Denison hydraulic pressing station on a dial-indexing table. Engineering judgment and experience indicate the availability of this machine will be at least 90 percent; this value will be used in this prediction.

Electronic Component Machines

Six of the machines in the XM587E2/XM724 fuze automated assembly line (part A) are expected to be computer-controlled electronic component sequencing and insertion machines. Machines AS1 and AS2 would be sequencers, machines AS3 and AS4 would be axial-leaded component inserters, machine AS5 would be a transistor insertion machine, and machine AS6 would be a DIP component insertion machine. These could be essentially off-the-shelf machines such as manufactured by Universal Instruments of Binghamton, New York.

No known RAM data currently exist on machines of this type, other than what can be obtained verbally from various manufacturers and users of similar equipment. This type of information was obtained by telephone from personnel at Universal Instruments and from cognizant production personnel at Honeywell locations in Minneapolis, Minnesota, Tampa, Florida, Brighton, Massachusetts and Arlington Heights, Illinois, where Universal Instruments sequencing and insertion equipment similar to that anticipated for this program have been in use for

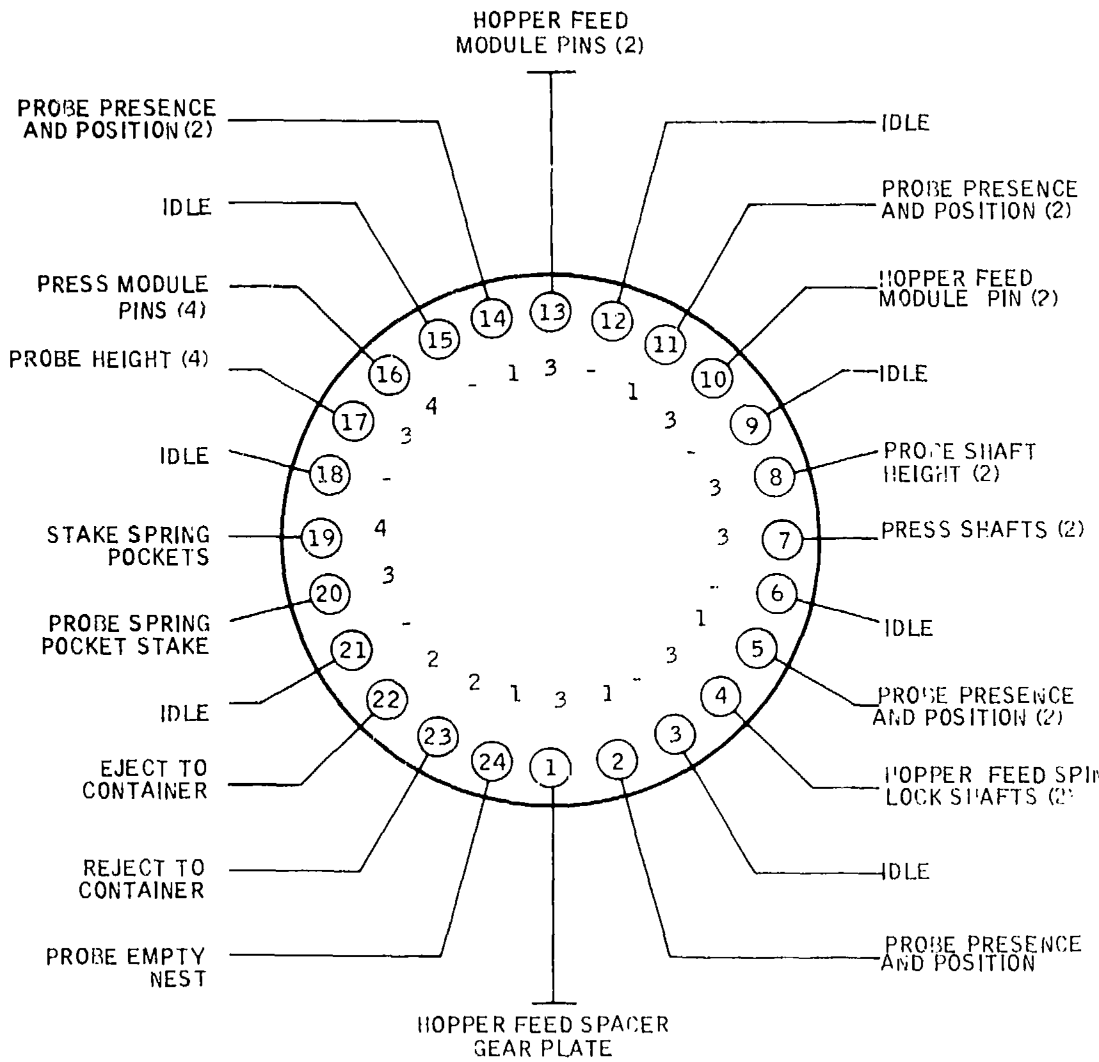


Figure B-4. Dial schematic, machine S1 - S&A module lower subassembly operation 1

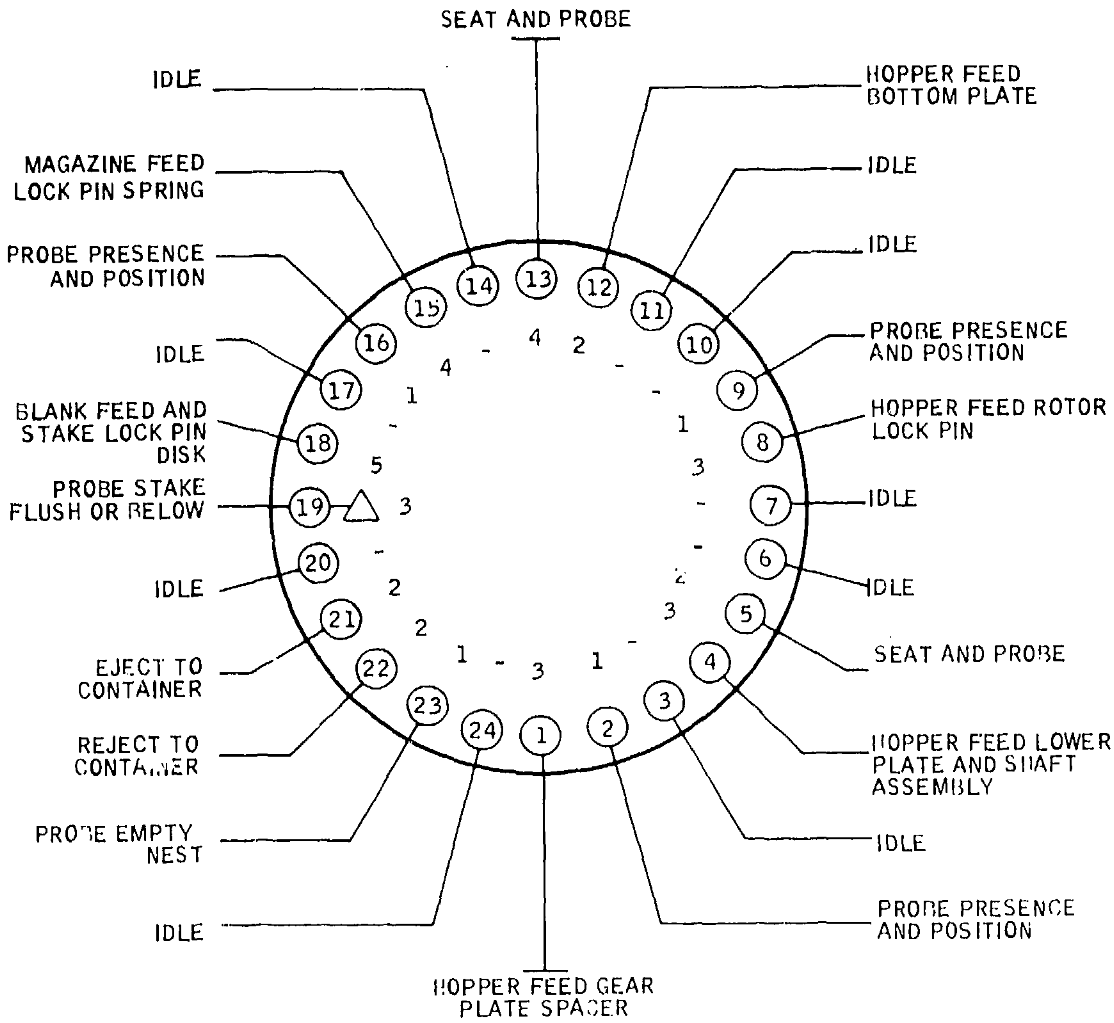


Figure B-5. Dial schematic, machine S2 - S&A module lower subassembly operation 2

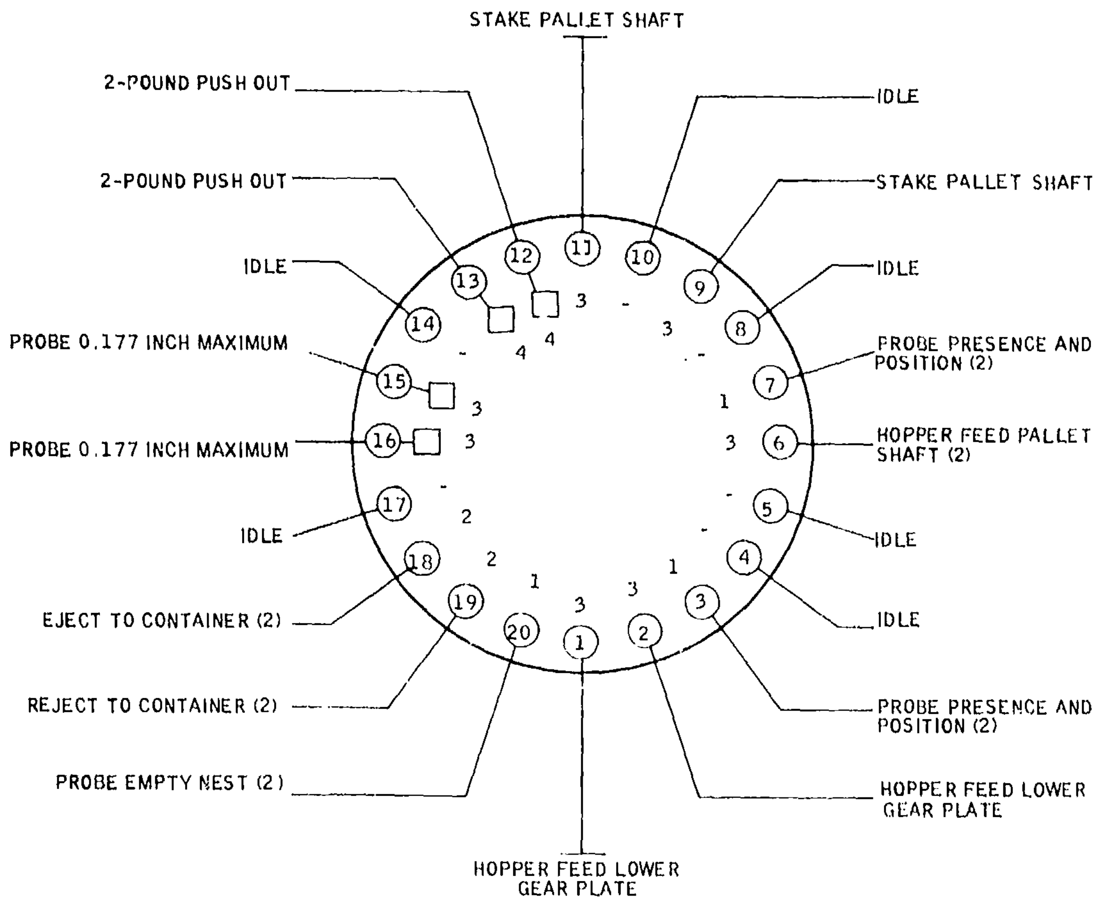


Figure B-6. Dial schematic, machine S3 - lower plate and shaft assembly

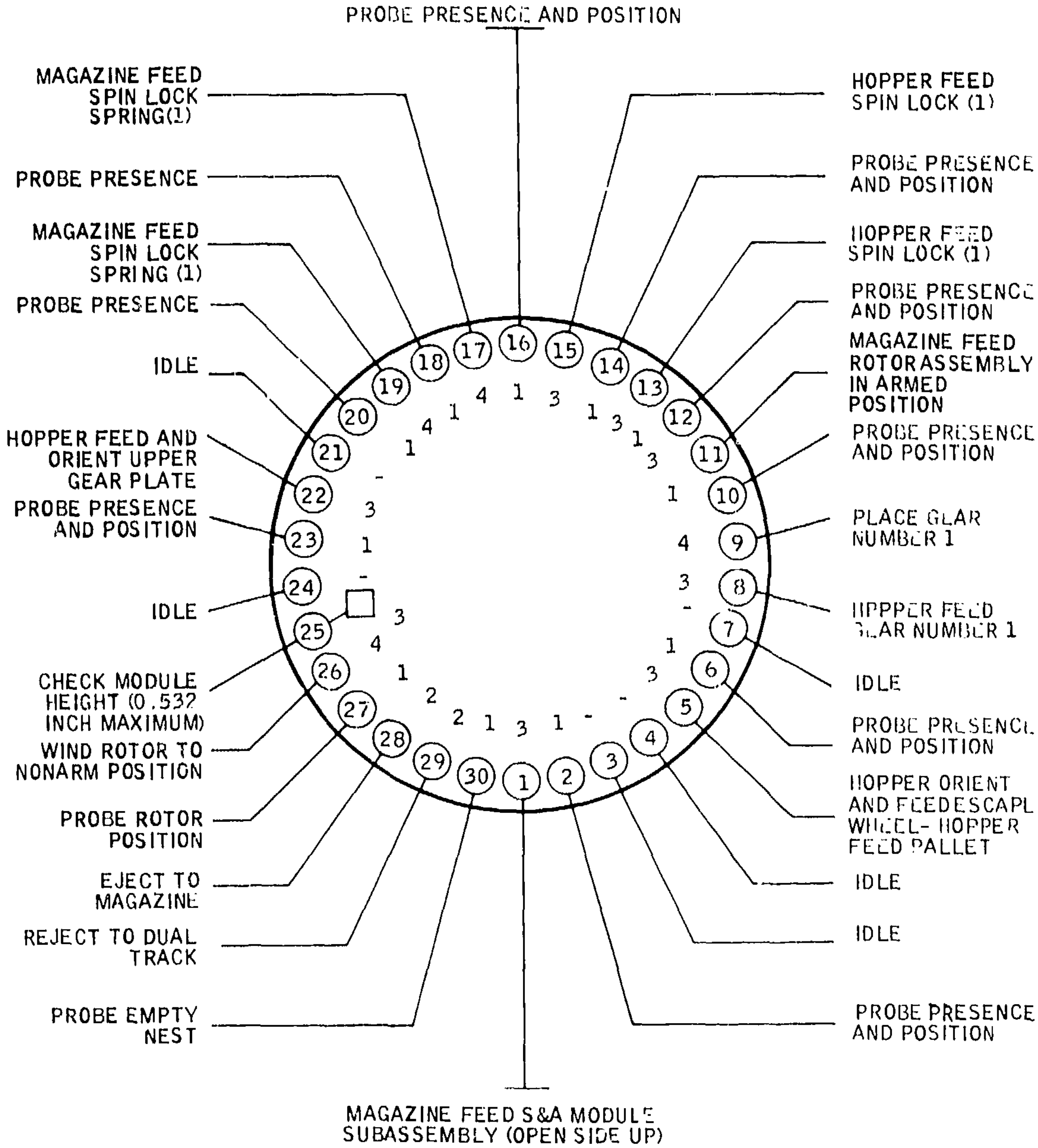


Figure B-7. Dial schematic, machine S5 - S&A module subassembly operation 1 (gear train)

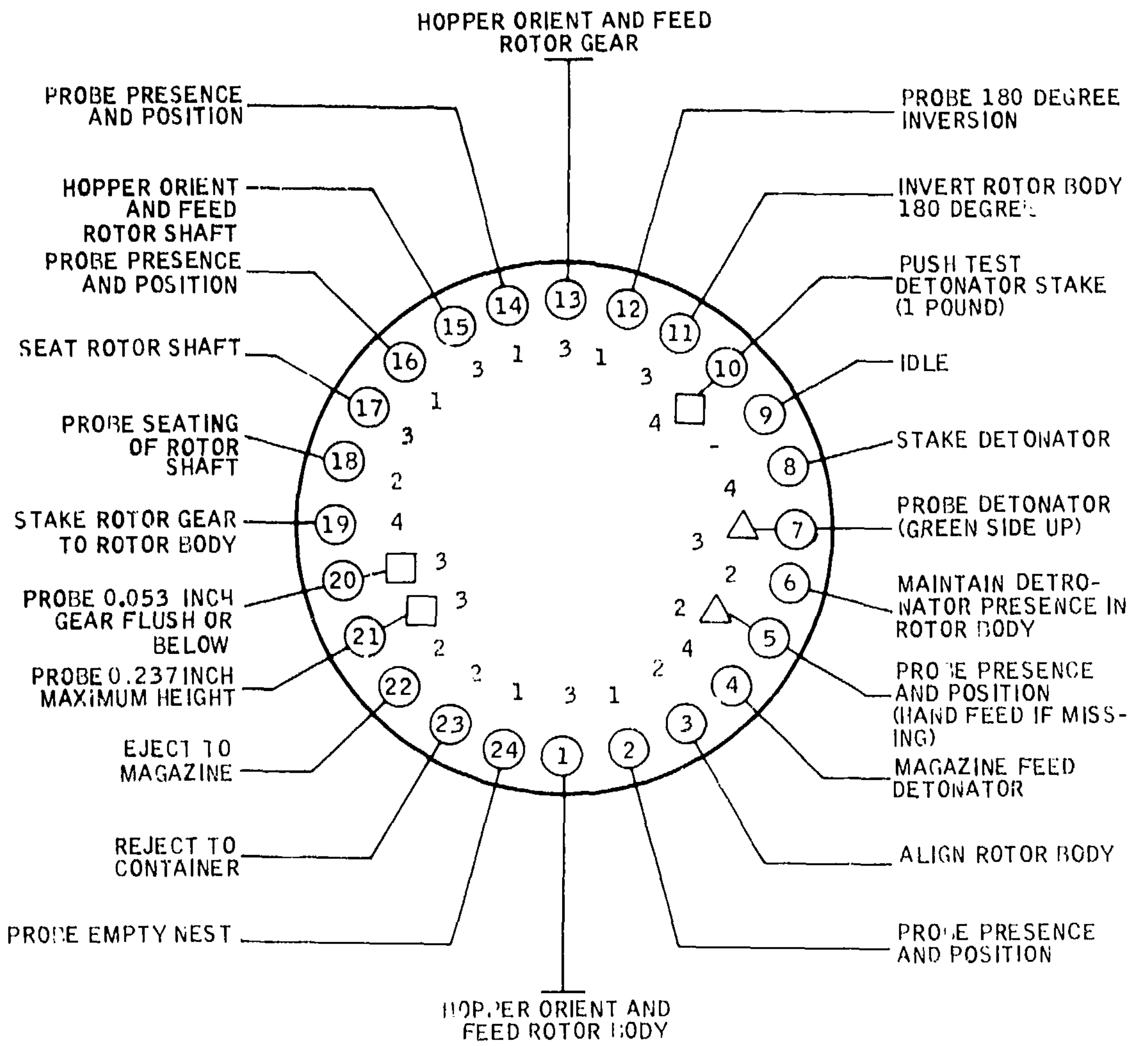


Figure B-8. Dial schematic, machine S6 - rotor assembly

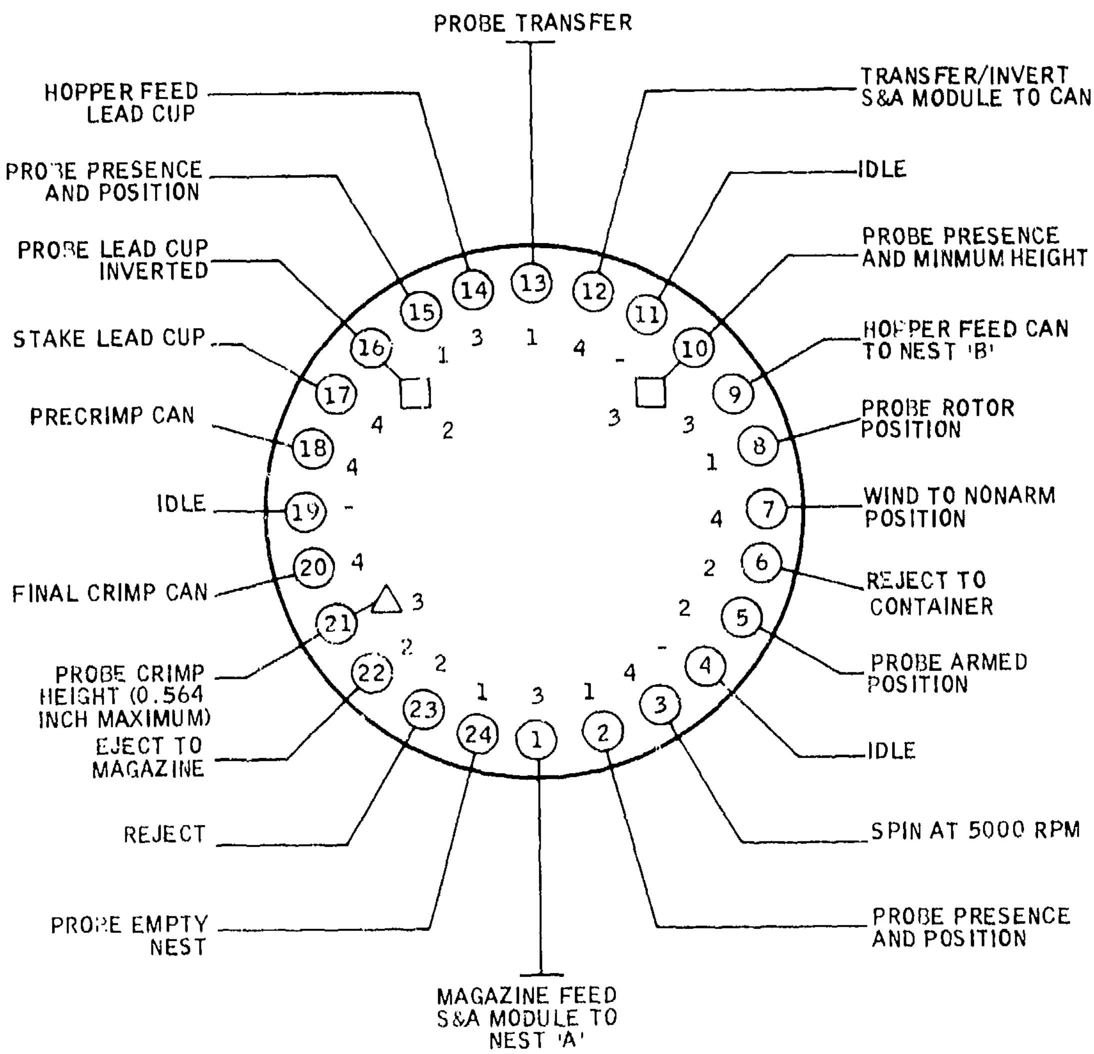


Figure B-9. Dial schematic, machine S8 - S&A module subassembly operation 2 (lead cup)

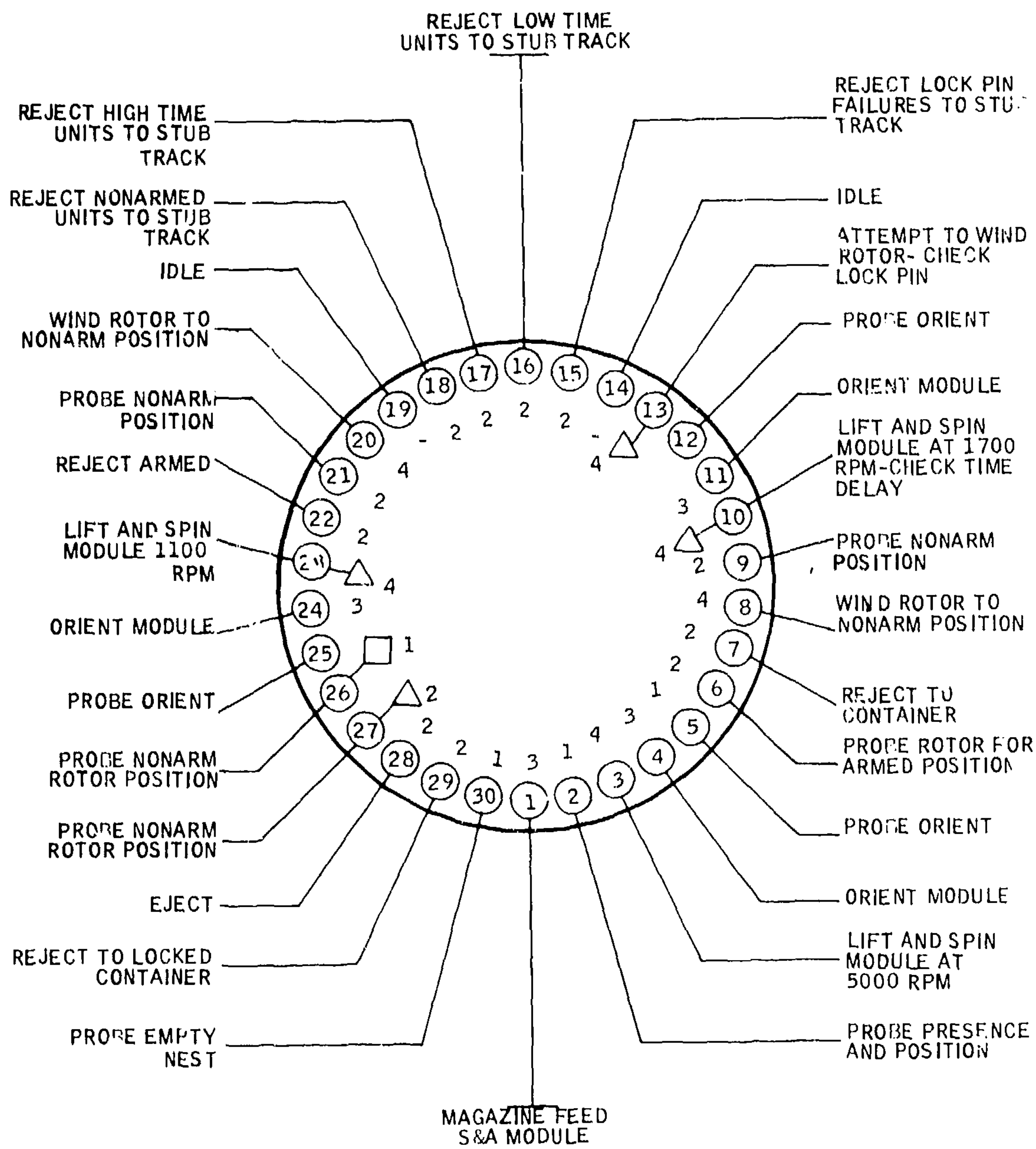


Figure B-10. Dial schematic, machine S9 - S&A module assembly operation 1

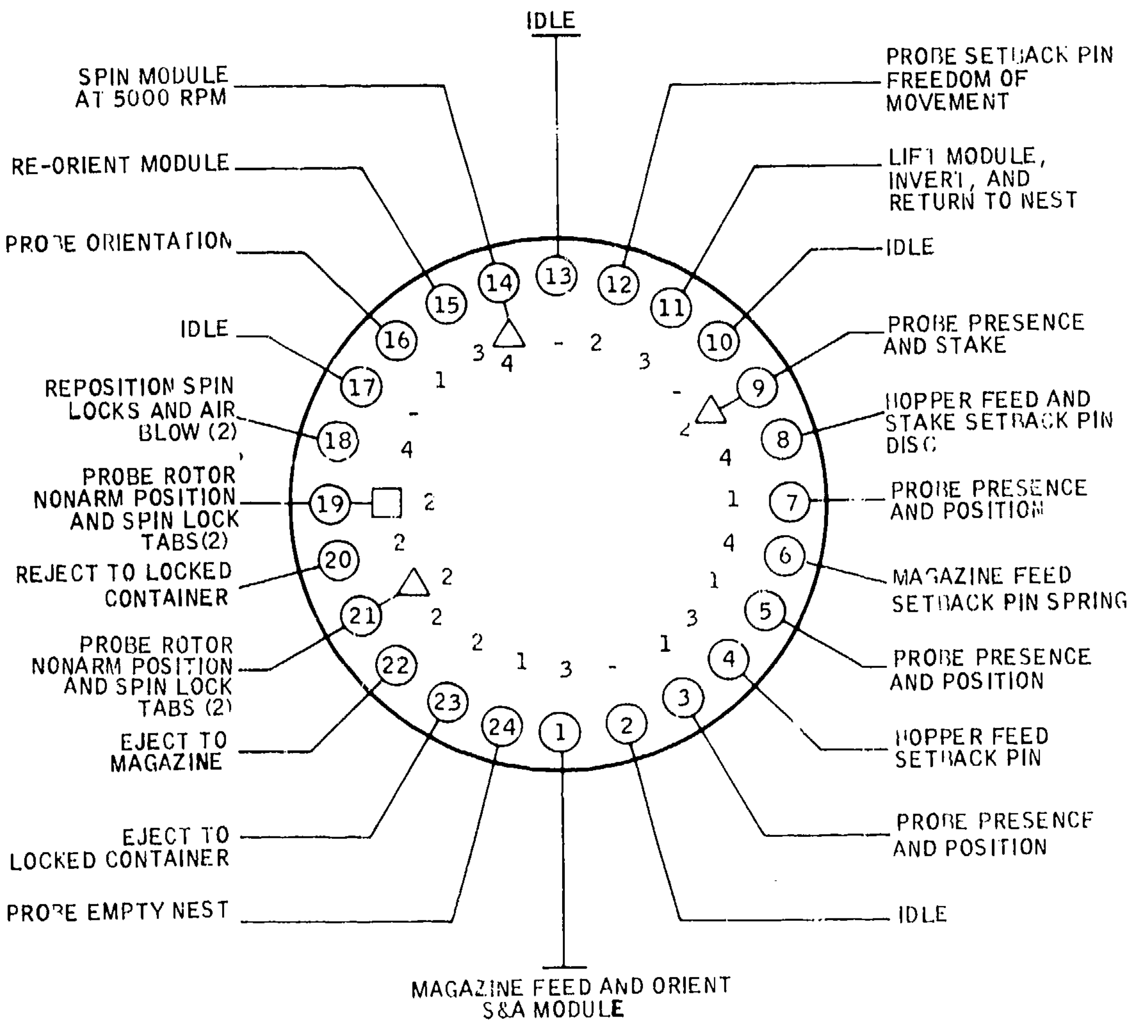


Figure B-11. Dial schematic, machine S10 - S&A module assembly operation 2 (setback pin)

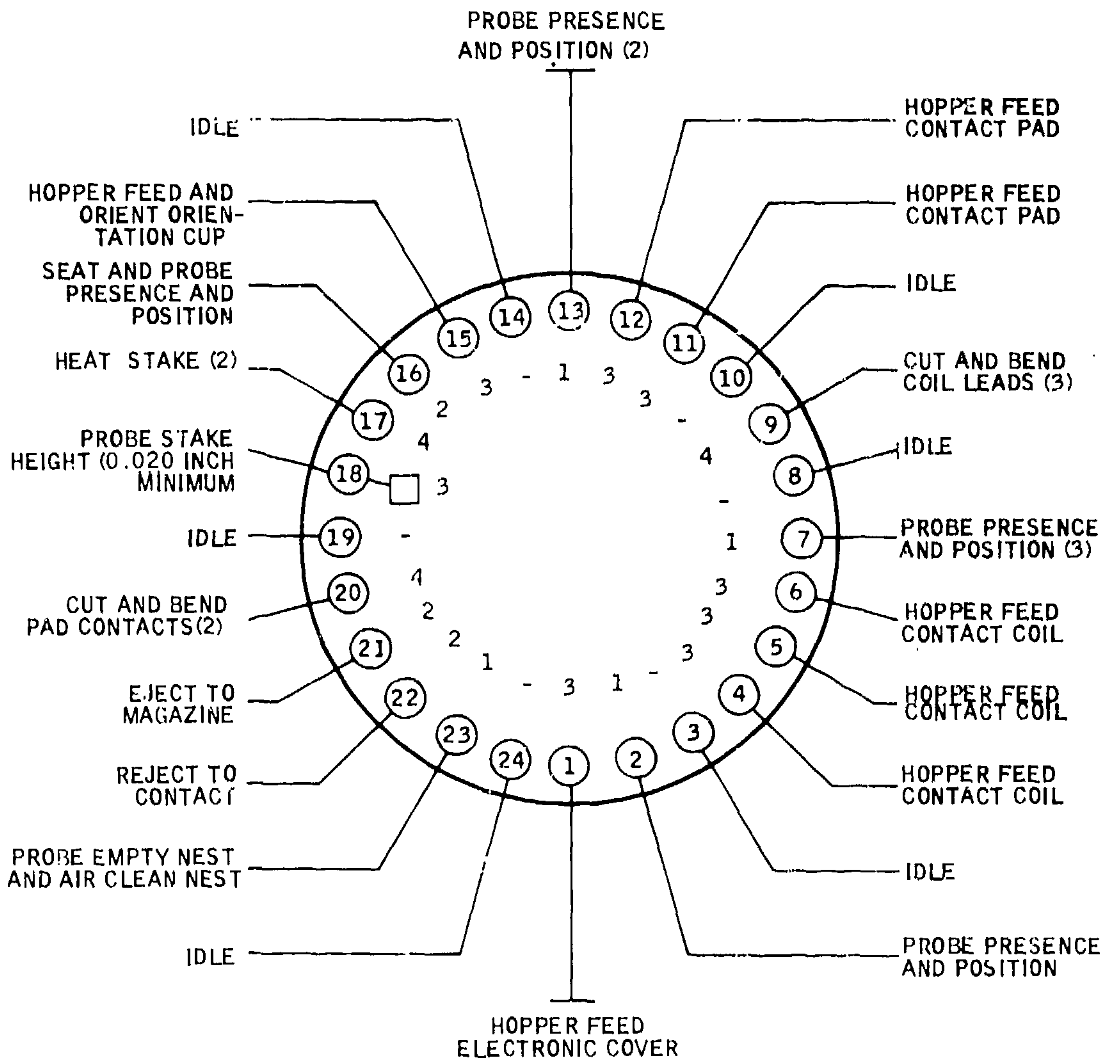


Figure B-12. Dial schematic, machine E1 - electronic cover and orientation cup assembly

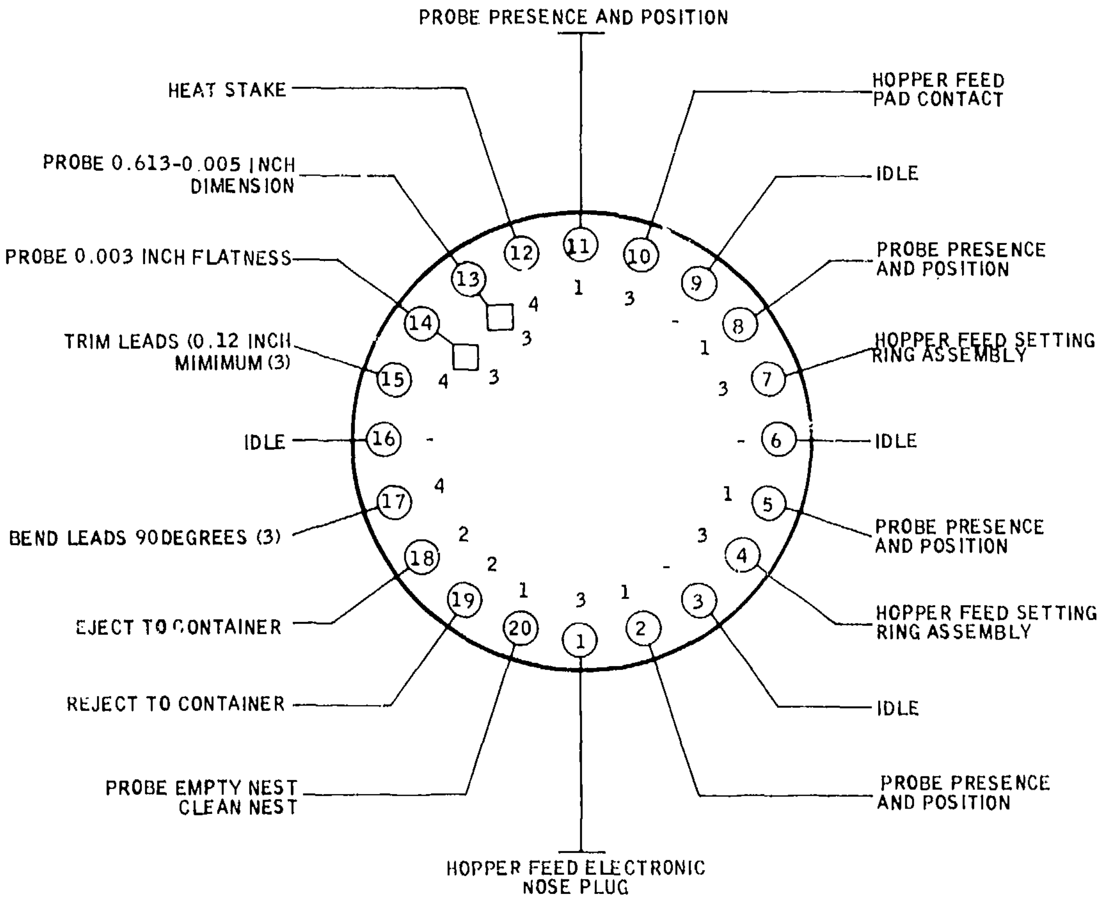


Figure B-13. Dial schematic, machine E2 - setting ring and nose plug assembly

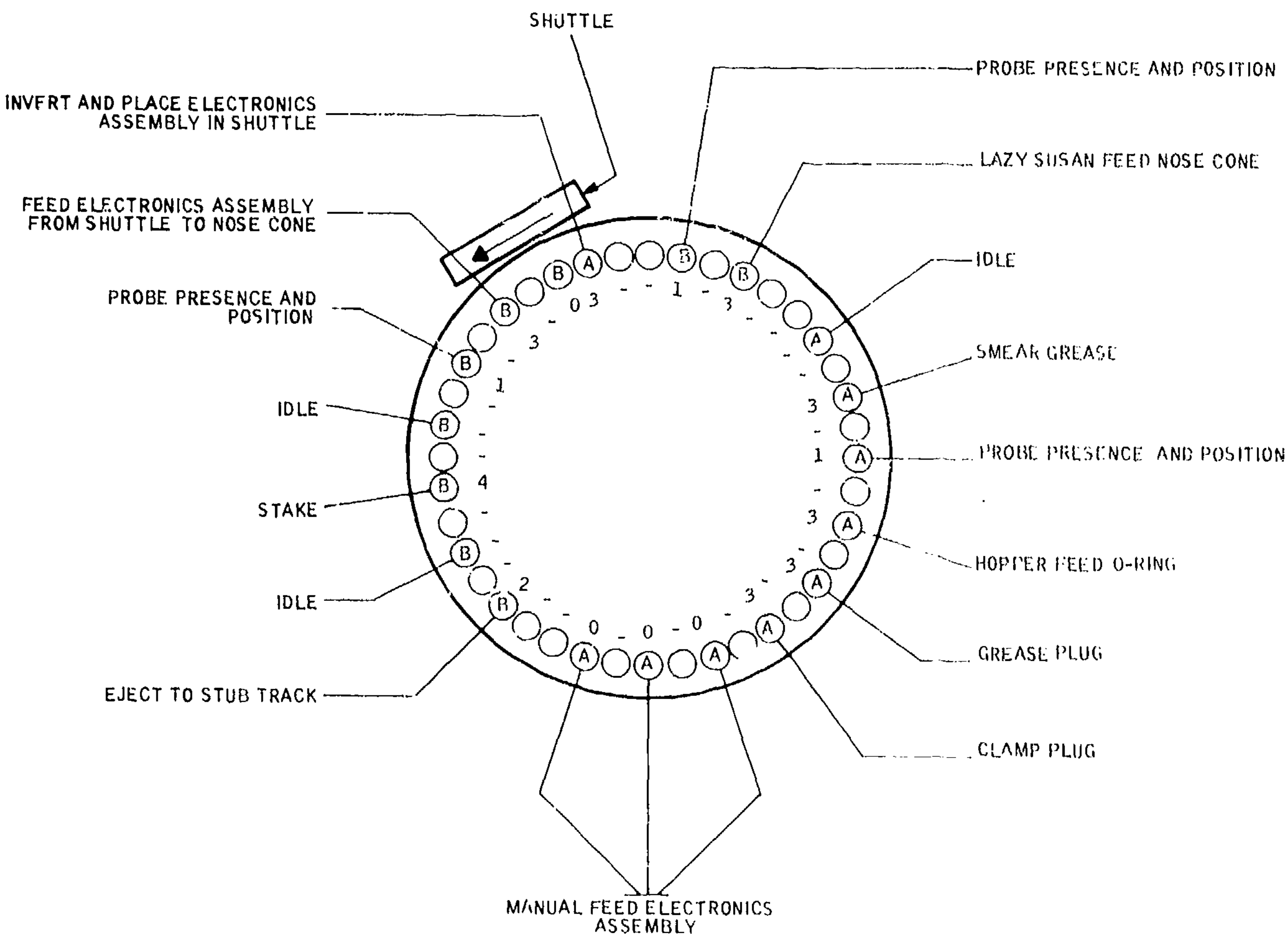


Figure B-14. Dial schematic, machine E3 - electronics and nose cone assembly

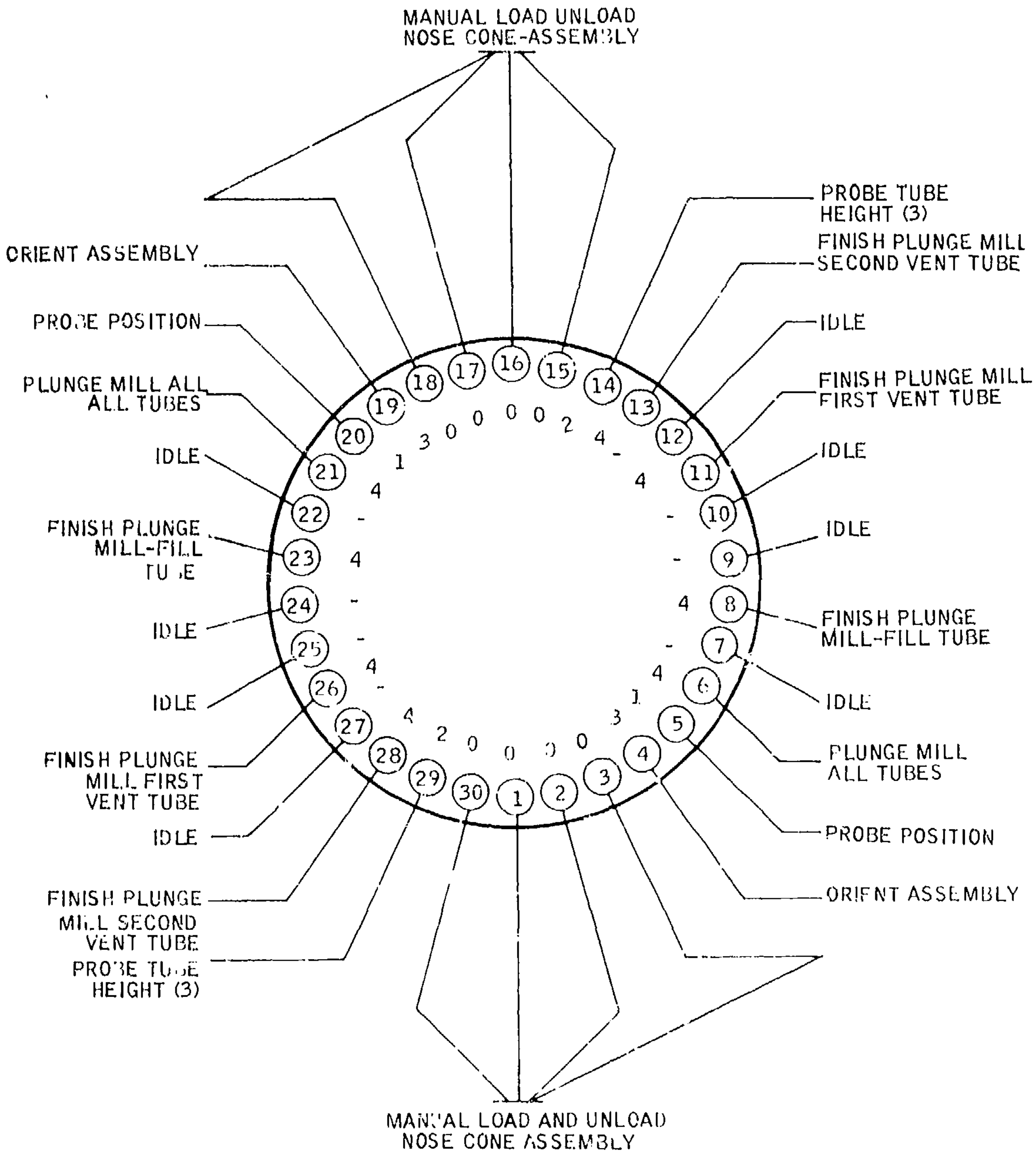


Figure B-15. Dial schematic, machine E4 - nose cone trim machine

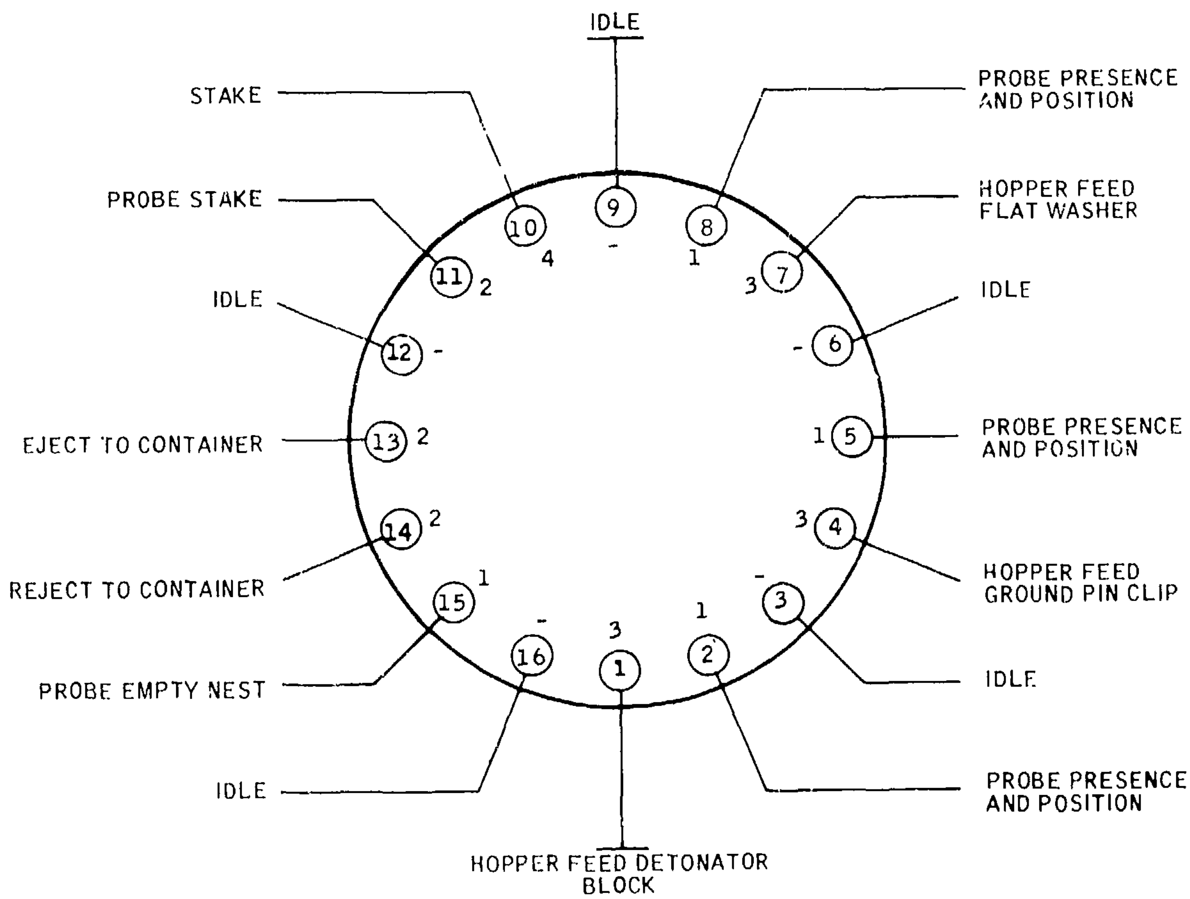


Figure B-16. Dial schematic, machine F1 - detonator block assembly operation 1

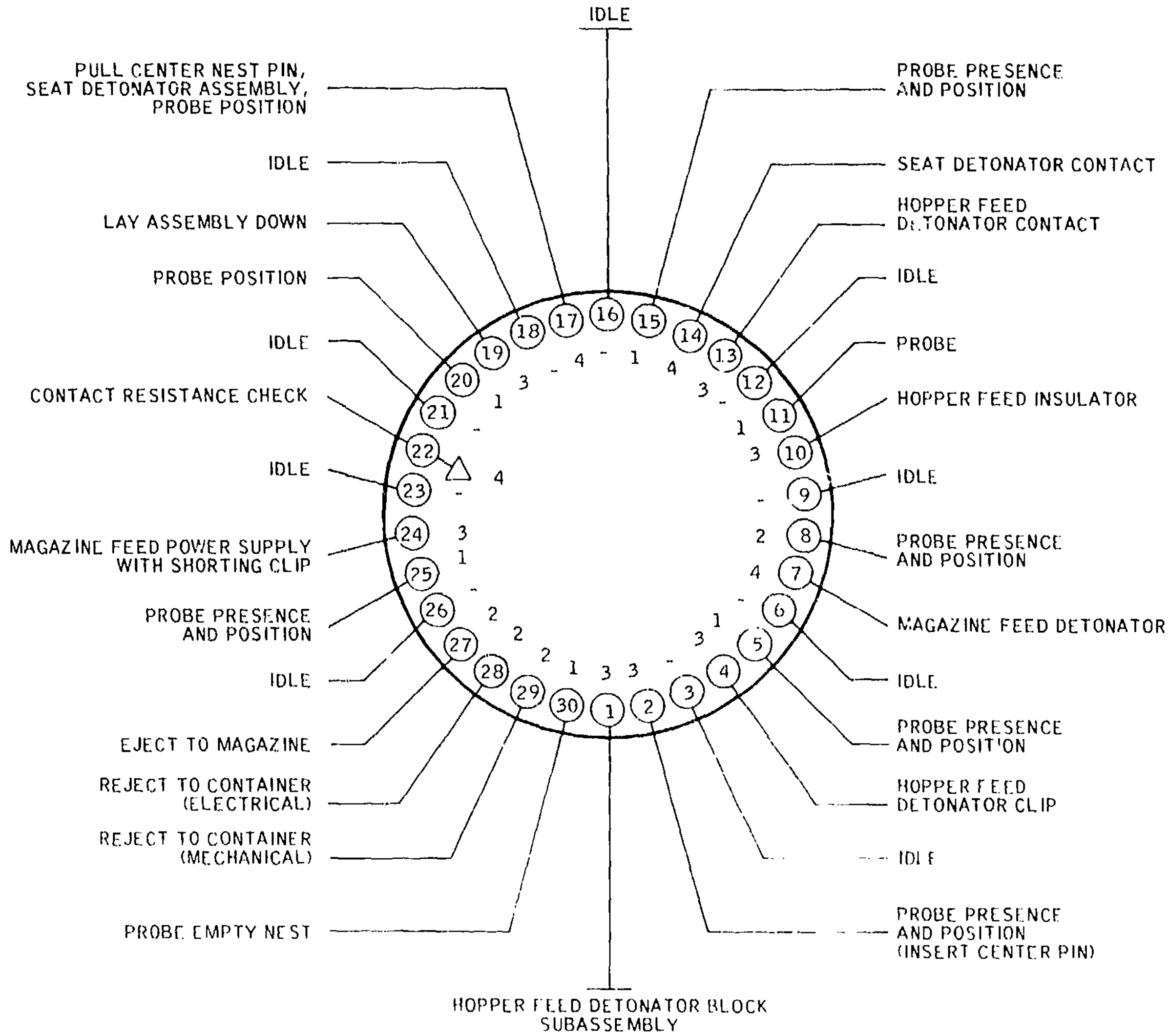


Figure B-17. Dial schematic, machine F2 - detonator block assembly operation 2

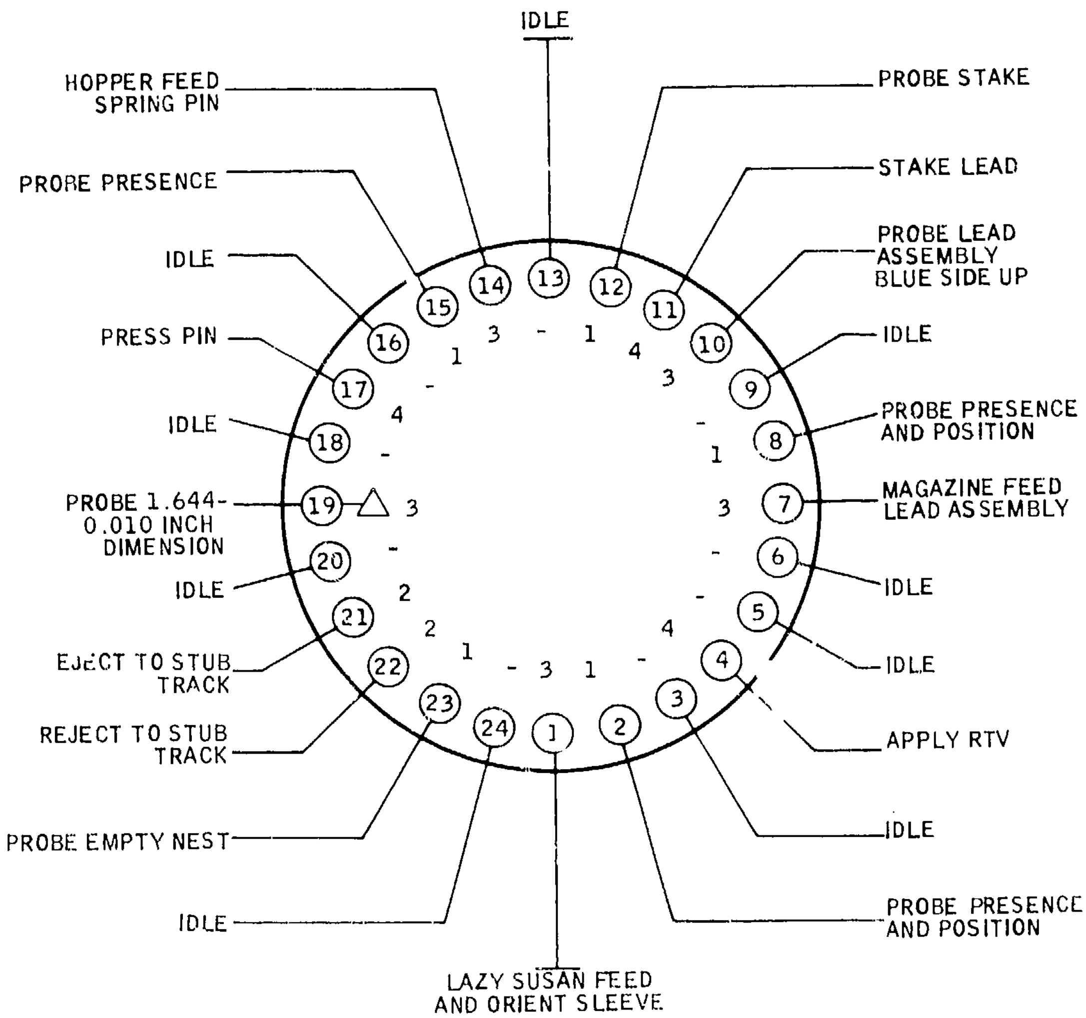


Figure B-18. Dial schematic, machine F3 - rear fitting assembly operation 1

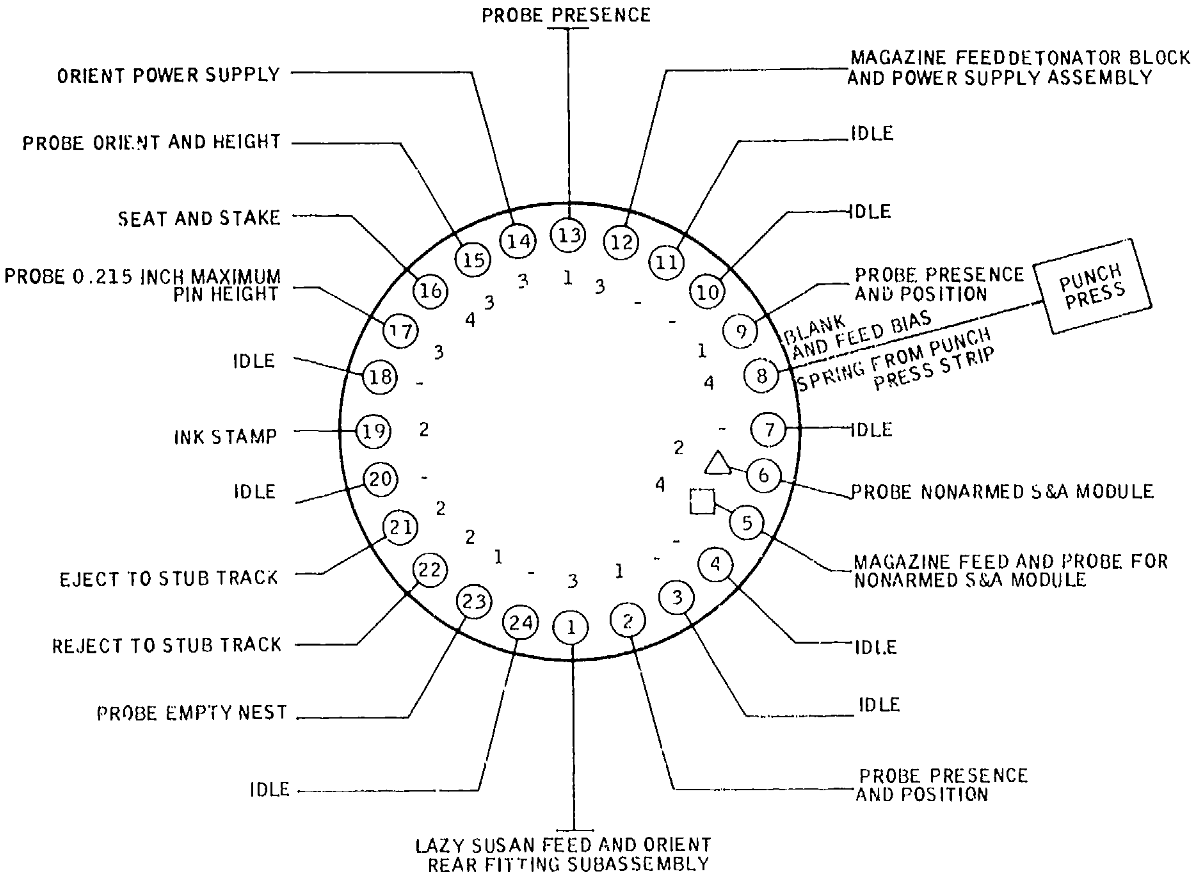


Figure B-19. Dial schematic, machine F4 - rear fitting assembly operation 2

TABLE B-III. PREDICTED RAM CHARACTERISTICS, DIAL-INDEX AUTOMATED ASSEMBLY MACHINES

S&A Module Assembly Machines			
Machine Number	MTBF (Hours)	MTTR (Hours)	Availability (Percent)
S1	6.684	1.335	83
S2	5.843	1.750	77
S3	7.247	1.329	85
S5	5.073	1.399	78
S6	5.068	1.393	79
S8	4.807	1.481	76
S9	4.961	1.478	77
S10	6.527	1.451	82

Fuze Assembly Machines			
Machine Number	MTBF (Hours)	MTTR (Hours)	Availability (Percent)
E1	5.802	1.371	81
E2	6.660	1.384	83
E3	7.305	1.352	84
E4	4.626	1.568	75
F1	13.921	1.320	91
F2	5.400	1.410	79
F3	7.219	1.420	84
F4	7.171	1.414	84
F5 (1)	13.5	1.5	90

(1) Crimp machine F5 does not have a dial schematic at this time. The RAM values are based on engineering judgment and related experience. It is to be purchased commercially and is expected to include a pressing station on a dial-indexing table.

one and one half to six years. Results of these conversations are summarized in the following paragraphs:

- In a discussion with a sales representative from Universal Instruments, it was stated that machine availability varies depending upon the user's maintenance facilities, spare parts supply, and training personnel. The following machine availability rates could be expected on Universal machines located in a facility comparable to those at Honeywell:

  - Axial-leaded component inserter - 95 percent
  - Transistor inserter - 95 percent
  - Sequencer - 99 percent
  - DIP (component) inserter - 90 percent

- Honeywell Residential Division, Minneapolis, has one Universal Instruments model 6288 inserter (single head) which is about one to one half years old. Very few breakdowns have been experienced (one power supply failure has occurred and three encoder light bulbs have failed - the latter is improved on newer models). When the machine was used for only 25,000 insertions per day (about two-thirds of a shift per day), maintenance took about three hours per week. It is now used for about 100,000 insertions per day (three shifts five days per week plus two shifts on Saturdays) and requires about six hours per week for maintenance. This machine is reportedly easy to work on.

  Certain parts do wear and need to be replaced. Parts tend to be expensive; they are available from Universal Instruments in about three days (sooner from the Honeywell Arlington Heights, Illinois plant where more Universal Instruments machines are used and a good supply of spare parts exists).

- Honeywell Peripheral Operations, Tampa, Florida, purchased a computer-controlled DIP component inserter three years ago. A second DIP component inserter and a VCD axial-leaded component inserter were purchased two years ago. On a one-shift basis, with a second shift for overflow work when necessary, these machines average about 16 hours downtime per month. Each machine requires a few minutes for cleaning and adjustment every

couple of days and a repair every couple of months (repairs often involve an electronic problem that may take a day or longer to solve). Much more downtime occurred during the first few months of machine operation. A good setup man is very important in minimizing downtime. Output averages about 16,000 insertions per shift with numerous printed wiring board configurations.

- Honeywell Computer Operations, Brighton, Massachusetts, has five Universal machines (about four to six years old) including:

  - Two Universal Instruments model 6785 inserters for integrated circuits
  - Two Universal Instruments model 6284 axial-leaded component inserters
  - One Universal Instruments model 2581 sequencer

  During a recent five month period (February - June 1976), there were 182 hours of machine downtime and 3600 hours of machine run time, or about five percent downtime. At the beginning of this period, the machines were on a one-shift basis, but were then boosted to two shifts five days per week for several months. Machine availability had been about 70 percent before a major effort was made to improve output. This effort included adding a second technician on the first shift (there is one technician on the second shift as well) and spending over $8,000 for upgrading the machines, including adding computer storage capacity and replacing worn parts.

- The Honeywell Commercial Division, Arlington Heights, Illinois, has four Universal Instruments inserters and one sequencer purchased in 1972 (three machines) and 1975 (two machines). They are operated in two shifts six days per week and average about 50,000 insertions per week. About $10,000 per year is spent on parts for the five machines. Most of the repairs are on head tooling that wears; replace modules and then repair the old modules. The sequencer requires practically no maintenance; inserters are scheduled for maintenance once each week, or approximately one day per machine per month. The Production Supervisor estimates that all five machines are available 80 percent of the time.

Table B-IV indicates the availability values arrived at based on the preceding information from the electronic component machine manufacture and users (MTBF and MTTR estimates are very rough estimates due to the limited data).

TABLE B-IV. ELECTRONIC COMPONENT MACHINES, PREDICTED AVAILABILITY VALUES

Machine Number	Machine Description	Predicted Availability (Percent)	MTBF (Hours)	MTTR (Hours)
AS1	Axial-Leaded Component Sequencer	98	73.5	1.5
AS2	Axial-Leaded Component Sequencer	98	73.5	1.5
AS3	Axial-Leaded Component Inserter	95	28.5	1.5
AS4	Axial-Leaded Component Inserter	95	28.5	1.5
AS5	Transistor Inserter	95	28.5	1.5
AS6	DIP Component Inserter	90	13.5	1.5

These are preliminary predicted values for unscheduled repairs/maintenance based on limited data for throughly debugged mature machines operating in an established high-volume production environment with appropriately trained operators and repair personnel assigned to the machines and with necessary spare parts readily available. These values do not reflect short stoppages; i.e., those that do not require maintenence personnel to remedy short stoppages must be reflected in a separate efficiency factor for each machine and do not necessarily correlate with availability. For example, a sequencer might have a significantly lower operation efficiency than an inserter, but a higher availability.

Wave Soldering Machine

The soldering of printed wiring boards is expected to be accomplished on a wave soldering machine such as the model 517-PCI machine made by Electrovert Inc. This includes an inclinable conveyor, a foam fluxer, a combination flux dryer and panel preheater, and a Model MSC-BR wave cleaner.

To arrive at a preliminary RAM prediction for the wave soldering equipment, the manufacturer and several users of similar equipment were contacted. The consensus is that most of the downtime is due to routine maintenance and cleaning that should be scheduled on a daily and weekly basis. For example, it is recommended that one half hour be planned for cleaning, etc., daily and about four hours weekly for cleaning the pump and fluxer aerater. Unscheduled downtime is minimal if properly maintained. The heaters are expected to last one to two years or longer, and can be replaced in one half hour (wave heater) to two hours (panel heater) according to the manufacturer. Fuses, belts, and heaters should be kept on hand.

The following preliminary RAM values reflect the estimated unscheduled wave soldering equipment downtime; other factors must reflect the routine maintenance:

MTBF (Hours)	MTTR (Hours)	Availability (Percent)
19	1	95

Potting Dispenser For E-Head

The potting or encapsulation system provides for the automated potting of the fuze electronics assembly using a silicon-filled epoxy consisting of a base mixture and a hardener, mixed in a specific ratio. Each assembly uses approximately 0.25 pound of material, and the processing time for encapsulation is expected to be about 4.5 seconds per assembly.

A similar potting system has been used by Honeywell in the FMU-61 fuze production line. Experience with this system was considered in estimating the following preliminary RAM values for the XM587E2/XM724 fuze E-head potting system:

MTBF (Hours)	MTTR (Hours)	Availability (Percent)
12	1	92

It must be remembered in calculating machine output that the RAM values reflect only unscheduled downtimes and do not consider scheduled maintenance, which, in this case, may involve one half hour for start up, one half hour for shutdown and cleanup, and one fourth hour for a mixture check each time the machine is run. Startup and shutdown times are much more significant for the 1-8-5 (single shift) production schedule than for a three-shift schedule because continuous running can occur on a three-shift schedule.

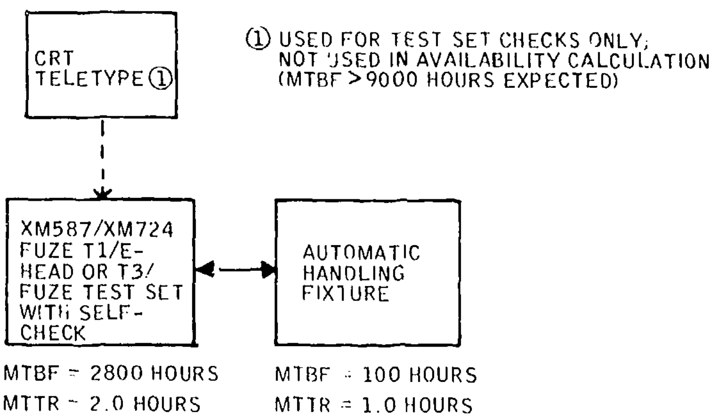
Test Stations

Two types of test stations are planned for the production program - E-head (T1 and T2), and fuze, (T3), test stations. The T1 E-head test station will functionally test the E-head prior to potting and register go/no-go data. The T2 E-head test station will functionally test the E-head after potting and record variables data on magnetic tape. The T3 fuze station will set and interrogate fuzes and register go/no-go data. Both test station types will be patterned after the XM587E2/XM724 fuze acceptance tester used under Contract DAAG39-75-C-0157. The T1 E-head test stations (figure B-20), consist of an E-head test set and an automatic handling fixture. The T2 E-head test station (figure B-21), consists of an E-head test set, an automatic handling fixture, and a magnetic tape unit.

Availabilities of 988 and 989 percent have been predicted for the T2 E-head and T1 E-head/T2 fuze test stations, respectively. These values are based on the following expected MTBF and MTTR values for a single station; multiple stations will result in correspondingly lower overall MTBF and availability values:

	MTBF (Hours)	MTTR (Hours)	Availability (Percent)
E-Head	92	1.1	988
Fuze	96	1.1	989

The MTBF and MTTR data used in determining the above values are based on Honeywell experience with similar equipment. The test set MTBF is based on actual operating/failure experience with the present XM587E2/XM724 fuze acceptance tester; the MTTR is based on experience, with allowance for self-check features. The magnetic tape unit MTBF and MTTR values are based on Honeywell computer and test equipment experience. The handling fixture MTBF and MTTR values are based on Honeywell automated assembly equipment experience.



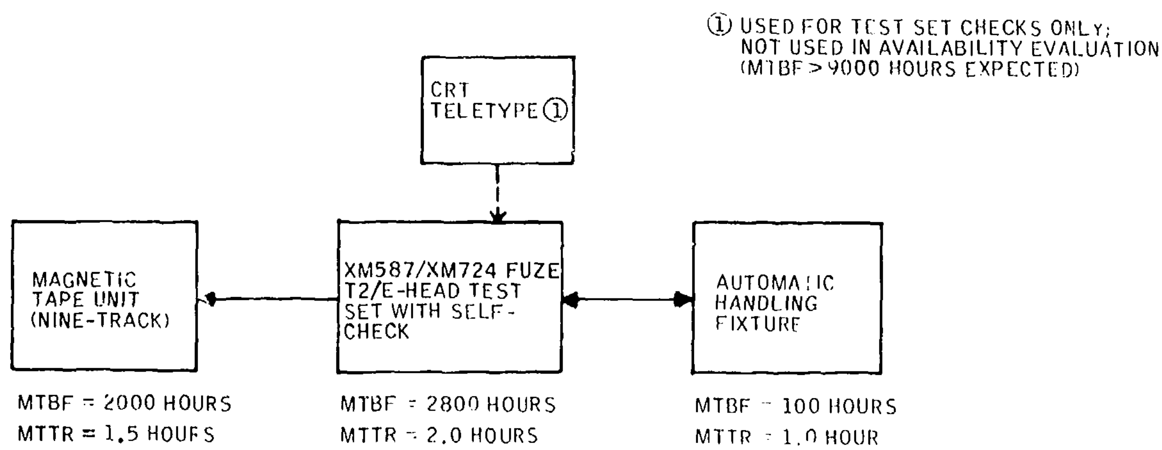
RAM VALUES FOR A SINGLE STATION:

$MTBF_{TEST\ STATION}$ = 96 HOURS

$MTTR_{TEST\ STATION}$ = 1.1 HOURS

$AVAILABILITY_{TEST\ STATION}$ = 98.9 PERCENT

Figure B-20. Block diagram, T1 (E-head) and T3 (fuze) test stations



RAM VALUES FOR A SINGLE STATION:

$MTBF_{TEST\ STATION}$ = 95 HOURS

$MTTR_{TEST\ STATION}$ = 1.1 HOURS

$AVAILABILITY_{TEST\ STATION}$ = 98.8 PERCENT

Figure B-21. Block diagram, T2 (E-head) test station

APPENDIX C

XM587E2/XM724 FUZE BASIC PRODUCTION FACILITY PRELIMINARY HAZARDS ANALYSIS

INTRODUCTION

This appendix was prepared in response to DD Form 1423 Contract Data Requirements List, DAAG39-76-C-0048 with HDL.

This appendix documents an initial evaluation of the proposed automated assembly lines for the fuzes and related S&A module to identify potential safety hazards and how they may be prevented or controlled. Results of this preliminary hazards analysis should provide a basis for future design considerations relative to personnel safety as the components and layout of the basic production facility are further defined and are implemented.

SUMMARY AND RESULTS

The automated assembly line concepts analyzed is described in the main body of this report.

This preliminary hazards analysis essentially involved the following elements:

- Review of the proposed basic production facility concept.
- Discussion of potential hazards, hazardous materials, and possible preventive measures with cognizant production and design personnel and with appropriate material and safety specialists.
- Documentation of results (see Tables C-I through C-X).

Results of this analysis are summarized in Tables C-I through C-X. These tables provide the following information:

- Hazard/Location - Type of hazard, such as explosion, and the area or station number where the hazard may occur.
- Cause - Possible hazard causes (inadequate grounding, venting, guarding, shielding, etc.)

- Effects - Possible effects of the hazards (damage to equipment, injury to fingers, burns, etc.)

- Hazard Class -

  - Severity - Hazard level per MIL-STD-882 categories as follows:

    -- I - Negligible - Will not result in personnel injury or system damage.

    -- II - Marginal - Can be counteracted or controlled without injury to personnel or major system damage.

    -- III - Critical - Will cause personnel injury or major system damage, or will require immediate corrective action for personnel or system survival.

    IV - Catastrophic - Will cause death or severe injury to personnel, or system loss.

  - Probability - Estimated probability of occurrences.

    A - An occurrence in less than 1000 operations or cycles.

    B - An occurrence between 1000 and 10,000 operations or cycles.

    C - An occurrence between 10,000 and 100,000 operations or cycles.

    D - An occurence between 100,000 and 1,000,000 operations or cycles.

    E - An occurrence in more than 1,000,000 operations or cycles.

  - Cost:

    Standard - Countermeasures suggested for the design of the equipment normally planned into Honeywell equipment, where countermeasures are defined as possible preventive measures that should be implemented and monitored during future phases of the BPF program (appropriate venting, guarding, shielding, training, precautions, etc.)

A - Less than $500 additional cost.

B - $500 to $2000 additional cost.

C - $2000 to $10,000 additional cost.

D - Over $10,000 additional cost.

CONCLUSIONS

Results of this analysis indicate that various potential hazards and hazardous materials will be involved with production of the XM587E2/XM724 fuze and S&A module. Continuing emphasis on safety will be required throughout the program. The machine design countermeasures suggested in Tables C-I through C-X would essentially all be incorporated as standard practice on Honeywell-supplied equipment. Monitoring will also be necessary during production usage of some of the equipment, particularly where fumes may escape or explosive dust might accumulate. Noise levels should also be checked when all equipment is in use.

TABLE C-I. POTENTIAL MACHINE HAZARDS, MACHINE S6 - ROTOR ASSEMBLY

Hazard Location	Cause	Effects	Hazard Class			Countermeasures
			Severity	Probability	Cost	
Explosion - Station 4 (Feed of Detonators from Magazine)	M55 stab detonator jam or improper clearing of jam.	Damage to station is dependent upon number of detonators exploding. Fragments could injure personnel if appropriate shielding is not used.	II or III	D	Standard	Design machine to immediately stop if a part jams; separate detonators so one cannot initiate the next one at any time. Make clearing of jams, and any repairs, easy and safe. Provide shielding for worst case conditions.
Explosion - Station 8 (Staking Detonator)	Improper staking tool and/or nest adjustment.	Damage to staking tool and possibly to nest.	II	C	Standard	Design to ensure proper alignment and easy adjustment. Make nest open in center for venting of blast. Make tool easily replaceable and shielded from operator.
Explosion - Station 10 (1-Pound Push Test on Detonator)	Damaged push test probe, loose explosive, or very high force applied rapidly.	Damage to push test probe and possibly to nest.	II	E	Standard	Limit force that could ever be applied to a safe level. Make push test probe easily replaceable.

TABLE C-II. POTENTIAL MACHINE HAZARDS, MACHINE S3 - S&A MODULE SUBASSEMBLY OPERATION 2 (LEAD CUP)

Hazard Location	Cause	Effects	Hazard Class			Countermeasures
			Severity	Probability	Cost	
Fire or Explosion - Station 14 (Hopper Feed Lead Cups)	Lead cups jam due to damage or malfunction in station, and explosive powder leaks out and gets compressed or heated sufficiently to ignite or explode.	Possible damage to station depending upon whether some powder merely burns or whether lead(s) explode or a larger number burn.	II or III	E	Standard	Design machine to stop instantly if a jam occurs and avoid having compression or heat near or under lead cups. Visually check leads for damage and loose powder prior to use. Clean area periodically to prevent build-up of explosive powder.
Fire or Explosion - Station 17 (Stake Lead Cup)	Improper staking tool or nest adjustment.	Possible damage to staking tool and nest.	III	E	Standard	Design to ensure proper alignment and positive positioning of leads and rejection of improper leads or improper positioned leads. Ensure immediate stoppage if bad staking occurs or excessive force is applied. Make nest open in center for venting.
Fire or Explosion - Station 21 (Probe Lead Cup Crimp Height)	Damaged probe, loose explosive, or excessive force applied.	Possible damage to probe and nest.	II	F	Standard	Design probe so maximum possible force is not enough to cause ignition and make probe easily replaceable if replacement is likely to be needed. Provide shielding to protect personnel and prevent detonation of other explosive items. Inspect and clean station of explosive powder periodically.

TABLE C-III. POTENTIAL MACHINE HAZARDS - MACHINE S9 - S&A MODULE ASSEMBLY MACHINE OPERATION 1 (ARM CHECK)

Hazard/ Location	Cause	Effects	Hazard Class			Countermeasures
			Severity	Probability	Cost	
Explosion - Stations 3, 4, 5, 6, and 7	Accidental impact of (armed) M55 stab detonator sufficient to initiate it.	Flying fragments and possible damage to nest and/or tool.	II	E	Standard	Design to minimize such an occurrence and provide shielding to prevent personnel injury and detonation of other explosive items.

TABLE C-IV. POTENTIAL MACHINE HAZARDS, MACHINE S10 - S&A MODULE ASSEMBLY OPERATION 2 (SETBACK PIN)

Hazard/ Location	Cause	Effects	Hazard Class			Countermeasures
			Severity	Probability	Cost	
Explosion - Stations 14 through 20	Accidental impact of (armed) M55 stab detonator sufficient to initiate it.	Flying fragments and possible damage to nest and/or tool.	II	E	Standard	Design to minimize such an occurrence and provide shielding to prevent personnel injury and detonation of other explosive items.

TABLE C-V. POTENTIAL MACHINE HAZARDS, MACHINE E-4 -- NOSE CONE TRIMMING

Hazard Location	Cause	Effects	Hazard C[illegible]			Countermeasures
			Seve[illegible]	[illegible]	Cost	
Epoxy Dust - Stations 6, 8 11, 13, 21, 23, 26, and 28	Inadequate venting of dust (epoxy and ABS plastic).	Possible health effect if venting (vacuuming) not provided.	II		Standard	Provide venting (vacuuming) of dust at the source and also precautions for and training of operating and maintenance personnel and anyone involved with the waste disposal to prevent air or water contamination.

TABLE C-VI. POTENTIAL MACHINE HAZARDS, MACHINE F2 - DETONATOR BLOCK ASSEMBLY OPERATION 2

Hazard/ Location	Cause	Effects	Hazard Class			Countermeasure
			Severity	Probability	Cost	
Explosion - Station 7 (Magazine Feed Detonators' and Following Stations.	(Electric) detonators jam, improper clearing of jam, or electrical discharge initiates detonator(s).	Damage to station is dependent upon number of detonators exploding.	II or III	D	Standard	Design machine to immediately stop if a part jams. Keep detonators separated at all times so one cannot initiate the next one or other explosives Make clearing of jams and any repairs easy and safe. Provide shielding for worst case conditions. Take precautions to minimize electrical buildup and discharge (increase humidity and use ground mats, etc., if necessary).
Explosion - Station 8	Electrical discharge or excessive force on detonator.	Possible damage to tool and nest.	II	E	Standard	Minimize electrical discharge potential by grounding, adequate humidity, etc., as necessary.
Explosion - Station 24 (Magazine Feed Power Suppl' with Shorting Clip)	Accidental short in power supply or excessive heat on power supply.	Possible damage to station and adjacent power supplies and also possibility of fragments and power supply contents.	II	D	Standard	Design assembly process (and power supply) to minimize the possibility of a short or excessive heat near the power supplies. Alert personnel to potential power supply hazards, require safety glasses with side shields, and provide appropriate shielding for personnel and other power supplies.

TABLE C-VII. POTENTIAL MACHINE HAZARDS, MACHINE F3 - REAR FITTING ASSEMBLY OPERATION 1

Hazard/ Location	Cause	Effects	Hazard Class			Countermeasures
			Severity	Probability	Cost	
Explosive or Fire - Station 7	Lead cups jam to damage or mal-function in station, and explosive powder leaks out, gets compressed, or heated sufficiently to ignite or explode.	Possible damage to station depending upon whether some powder merely burns or whether lead(s) explode or a larger number burn.	II or III	E	Standard	Design machine to stop instantly if a jam occurs and avoid having compress-ion or heat near or under lead cups. Visually check leads for damage and loose powder prior to use. Clean area periodically to prevent buildup of excessive powder.
Fire or Explosion - Station 11 (Stake Lead Cup)	Improper staking tool or nest adjustment.	Possible damage to staking tool and nest.	III	E	Standard	Design to ensure good alignment and positive positioning of leads and rejection of improper leads or improperly positioned leads. Ensure immediate stoppage if bad staking occurs or excessive force is applied. Make nest open in center for venting.

TABLE C-VIII. POTENTIAL MACHINE HAZARDS, MACHINE F4 - REAR FITTING ASSEMBLY OPERATION 2

Hazard/ Location	Cause	Effects	Hazard Class			Countermeasures
			Severity	Probability	Cost	
Explosion - Station 12 Feed Detonator Block and Power Supply Assembly and Following Stations	Inadequate short on detonator and electrical discharge initiates detonator.	Possible damage to station, and power supply rupture.	II	D	Standard	Design machine to immediately stop if a part jams. Keep detonators separated at all times so one cannot initiate the next one or other explosives. Make clearing of jams and any repairs easy and safe. Provide shielding for worst case conditions. Take precautions to minimize electrical buildup and discharge (increase humidity and use ground mats, etc., if necessary).
Punch Press	Inadequate shielding.	Possible finger or hand injury.	EE	E	Standard	Provide appropriate shielding interlocks to protect operation.

TABLE C-IX. POTENTIAL MACHINE HAZARDS, WAVE SOLDERING MACHINE

Hazard/Location	Cause	Effects	Hazard Class			Countermeasures
			Severity	Probability	Cost	
Burns - Hot Molten Solder and Flux.	Inadequate warning signs or guards where hazard exists.	Burns when molten solder (up to 500°F) is contacted by personnel.	II	D	Standard	Add appropriate warning signs, decals, shields, guards, and covers, etc., as appropriate. Provide face shields for operators.
Vapors and Fumes from Soldering and from Cleaning Solvents	Inadequate venting.	Possible longer-term health effects, headaches, etc.	II	D	Standard	Provide appropriate venting so fumes are drawn away from personnel. Use special safety containers, precaution signs, a 1-day supply maximum of solvent in area, and any other precautions as determined by safety/health specialists after installation, prior to production usage.

TABLE C-X. POTENTIAL MACHINE HAZARDS, ENCAPSULATION SYSTEM

Hazard/ Location	Cause	Effects	Hazard Class			Countermeasures
			Severity	Probability	Cost	
Vapors from potting and hardener.	Inadequate venting.	Possible skin damage (dermatitis) and longer-term health effects.	II	D	Standard	Seal the potting process to the maximum extent possible and provide appropriate venting. Also provide venting for safety relief valves that could emit toxic vapors if they function. Monitor air and keep below 50 percent of tolerance limit valve for the toxic materials involved or provide continuing medical monitoring of employees involved. Provide local washing facility, vapor masks, and other facilities if considered necessary by safety/health specialists. Train and alert operators, maintenance personnel, and others involved with the process and with the disposal of wastes from the area.

APPENDIX D

HANDLING OF ELECTROSTATIC-SENSITIVE ELECTRONIC ITEMS

Honeywell

GOVERNMENT AND AERONAUTICAL PRODUCTS DIVISION CODE IDENT NO 94580

SPECIFICATION NO. ES 8708

[redacted]

TYPE: ☐ SYSTEM ☐ DEVELOPMENT ☐ PRODUCT ☒ OTHER

TITLE: HANDLING OF ELECTROSTATIC SENSITIVE ELECTRONIC ITEMS

SIGNATURES		DATE
PREPARED BY	[illegible]	4/5/76
APPROVED BY PROJECT ENGR	[illegible]	4/7/76

REVISIONS

LTR	DESCRIPTION	DATE	APPROVAL	LTR	DESCRIPTION	DATE	APPROVAL
-	Originated	4/6/76					
	C CONTROL/ ERO 7642486						

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PAGE 1 OF 14
ES 8708

HONEYWELL C 225D

1.0 SCOPE

This document provides the minimum acceptable handling requirements necessary to insure the highest practical protection for specified items during all operations.

The controls described in this specification are recommended for any item defined as electrostatic sensitive in this document.

This specification is intended to provide division wide controls and is applicable to all departments handling electrostatic sensitive devices and assemblies.

2.0 APPLICABLE DOCUMENTS

Military:

MIL-S-19491	Semiconductor Devices, Packaging of
MIL-S-19500	Semiconductor Devices, General Specification for
MIL-S-38510	Microcircuits, General Specification for
MIL-M-55565	Microcircuits, Preparation for Delivery of
MIL-B-81705	Barrier materials, Flexible, Electrostatic Free, Heat Sealable

Other:

ASTM D257	D-C Resistance or Conductance of Insulating Materials

3.0 DEFINITIONS

The definitions included in MIL-M-38510 and MIL-S-19500 shall apply. Additional definitions established by this document, as well as others repeated for convenience, are listed in subsequent paragraphs.

3.0.1 ESD: Electrostatic Discharge

3.0.2 ESDS: Electrostatic Discharge Sensitive

3.0.3 Facility: A location, either commercial or governmental, where components or assemblies may be stored, handled, assembled, or tested.

3.0.4 Protected Areas: Any area in the facility where Category 1 or 2 parts and assemblies are handled or stored.

3.0.5 Category 1 Electronic Components: Components which are very sensitive to electrostatic discharge damage. Components include: microwave semiconductors, metal oxide semiconductor (MOS) devices with no input protection circuitry, dielectrically isolated semiconductors with internal capacitor contacts connected to external pins, and microcircuits utilizing N+ guard ring construction.

3.0.6 Category 1 Assemblies: Unless otherwise specified, any assembly having two or more pins directly connected to a Category 1 component with no parallel interconnections.

3.0.7 Category 2 Electronic Components: Components which are sensitive to electrostatic discharge damage. Components include: MOS devices with input protection, junction FET's, Hybrids utilizing any of the parts listed in Categories 1 and 2, and precision ladder networks.

3.0.8 Category 2 Assemblies: Unless otherwise specified, any assembly having two or more pins directly connected to a Category 2 component with no parallel interconnections.

4.0 QUALITY ASSURANCE PROVISIONS

4.1 RESPONSIBILITY

Quality Engineering is charged with the responsibility of verifying that devices or assemblies covered by this specification are properly handled and that the necessary instructions are in effect.

This verification should take the form of review of handling procedures, layouts, and inspection procedures. Formal and regular audits are also recommended to insure compliance to this specification.

4.2 TRAINING

All personnel involved in the handling of ESDS devices should receive instructions and training in the implementation of the requirements and guidelines herein.

4.3 SPECIFIC RESPONSIBILITIES

The following areas of responsibility are shown as recommendations. Although product groups may choose to assign the listed functions to different groups it is necessary that these tasks are accomplished and areas of responsibilities be defined.

4.3.1 Categorization of parts - Design Engineering shall be responsible for categorizing all electrical parts. This categorization can then be shown on the part drawings or in the case of customer drawings, a list of parts used for that productshall be generated.

4.3.2 Production processes - Production Engineering shall insure that production operations (Assembly & Test) are accomplished using precautions as defined in this document.

4.3.3 Inspection Operations - Quality Engineering shall have the responsibility to insure all inspection operations are accomplished using precautions as defined in this document.

4.3.4 Packing & Shipping - Packaging Engineering shall evaluate Packing and Shipping practices on ESDS devices and insure adequacy.

4.3.5 Vendor Control - Quality Engineering shall insure that all necessary requirements are included in Purchase Orders to vendors supplying ESDS parts.

4.3.6 Material Handling/Stock/Receiving Dock - Packaging and Material Handling Engineering shall insure that the Material Handling Procedures reflect the precaustions in this document.

5.0 DETAIL REQUIREMENTS

The detail requirements contained in this section are defined to provide latitude in the control measures necessary for the protection of ESDS electronic components and assemblies by allowing alternative control measures. Table 1 summarizes the alternative control measures for electrostatic protection.

As described in Table 1, five acceptable/equivalent control measures (displayed as Control Measure 1, 2, 3, 4, 5) are listed. Any Category 1 control measure shall be considered more stringent than any Category 2 control measure. The facility at its option shall implement any control measure, equivalent or better, for the correspondigg category to be protected. The facility may implement different control measures in different areas of the facility to meet the requirements (e.g. for Category 2 components and assemblies, the facility's Receiving Inspection area could implement Control Measure 2 of Category 2 while an Assembly area could implement another control measure listed for Category 2 or 1).

As an illustration as to the use of Table 1, if Control Measure 2 of Category 1 is chosen then the following paragraphs of this document must be met.

5.1, 5.1.1, 5.1.4, 5.1.5, 5.1.6, 5.1.7, 5.1.8, 5.1.9, 5.2, 5.2.1.2, 5.2.2., 5.[illegible].2.2, 5.2.2.3, 5.2.2.4, 5.3, 5.3.1, 5.3.2, 5.3.3.

It should be noted that if Control Measure 2 is selected all requirements which are marked with an "x" in that column must be met. Any of the Control Measures shown provide approximately the same protection.

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TABLE 1 **SPECIFICATION NO.** ES 8708

Requirement Paragraph	Title	Category 1 Alternative Control Measures 1	2	3	4	5	Category 2 Alternative Control Measures 1	2	3	4	5
5.1	Facility	X	X	X	X	X	X	X	X	X	X
5.1.1	Relative humidity	X	X				X	X			
5.1.2	Relative humidity			X	X	X					
5.1.3	Ionized air blowers	X		X			X		X		
5.1.4	Test equipment		X		X	X		X		X	X
5.1.5	Carpeting	X	X	X	X			X	X	X	
5.1.6	Trays, carriers, tote boxes, cushioning material and bags		X		X	X		X		X	X
5.1.7	Common ground		X	X	X	X			X	X	
5.1.8	Temperature chambers		X		X	X		X		X	X
5.1.9	Electrical equipment, tools, soldering iron, solder pots, flow soldering equipment	X	X	X	X	X					
5.1.10	Chairs or stools					X					
5.1.11	Grounded work station				X	X					X
5.2	Personnel	X	X	X	X		X	X	X	X	X
5.2.1.1	Smocks, gloves, finger cots	X	X	X	X		X	X	X	X	X
5.2.1.2	Wrist bracelets		X		X	X				X	X
5.2.1.3	Outer garment				X	X					
5.2.2.1	General	X	X	X	X	X	X	X	X	X	X
5.2.2.2	Component body handling	X	X	X	X	X	X	X	X	X	X
5.2.2.3	Protective covering		X	X	X	X					X
5.2.2.4	Power applied to leads	X	X	X	X	X	X	X	X	X	X
5.3	Packaging and storage	X	X	X	X	X	X	X	X	X	X
5.3.1	External leads of packaged electronic components and assemblies	X	X	X	X	X	X	X	X	X	X
5.3.2	Marking of containers	X	X	X	X	X	X	X	X	X	X
5.3.3	Packing material	X	X	X	X	X	X	X	X	X	X

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5.1 FACILITY

Category 1 and 2 electronic components and assemblies shall only be handled, stored or tested in protected areas of the facility meeting or exceeding the requirements for that category as shown in **Table** I.

5.1.1 RELATIVE HUMIDITY

The protected area's relative humidity shall be 40% or greater when measured with equipment accurate to ± 2% or better. Note: This requirement shall not preclude the facility representative's responsibility to ensure that adverse amounts of moisture are not present accelerating rust formation and other detrimental effects.

5.1.2 RELATIVE HUMIDITY

The protected area's relative humidity shall be 25% or greater when measured with equipment accurate to ± 2% or better. Note: This requirement shall not preclude the facility representative's responsibility to ensure that adverse amounts of moisture are not present accelerating rust formation and other detrimental effects.

5.1.3 IONIZED AIR BLOWERS

Ionized Air Blowers (capable of neutralizing voltages of 10,000 volts from an exposure distance of 3 feet in a period of 15 seconds or less) shall be placed at a maximum distance of 6 feet from the electronic component or assembly being tested or handled.

5.1.4 TEST EQUIPMENT

Test equipment shall have all exposed metallic surfaces electrically connected to the test equipment power system ground (200 ohms or less) when measured with a Simpson Ohmmeter Model 260, equivalent or better, RX10 scale.

5.1.5 CARPETING

Carpeting shall be prohibited in the protected area.

5.1.6 TRAYS, CARRIERS, TOTE BOXES, CUSHIONING MATERIAL AND BAGS

Trays, carriers, tote boxes, cushioning material and bags used to transport, store or hold electronic components or assemblies shall have a surface resistivity of less than 10^{12} ohms/square when measured per ASTM Test Method D257 or equivalent or better.

5.1.7 GROUNDING

Each protected area shall have all grounds connected to a common point, that point wired to earth ground (a cold water pipe is an acceptable ground).

5.1.8 TEMPERATURE CHAMBERS/BATHS

Temperature chambers shall be equipped with baffles or equivalent to prevent direct air flow over electronic components and assemblies present in the temperature chamber. Electronic components that have not been assembled shall be placed in containers with a surface resistivity of 10^{12} ohms/square or less when measured per ASTM Test Method D257 or equivalent or better.

Temperature Baths using Fluorinert (FC 77, FC 48) are acceptable for conditioning parts for test purposes. All metallic containers, etc. must be connected to Earth ground.

5.1.9 ELECTRICAL EQUIPMENT, TOOLS, SOLDERING IRONS, SOLDER POTS, FLOW SOLDERING EQUIPMENT

Soldering irons, soldering pots or flow soldering equipment shall be transformer isolated from the power line and be grounded. The resistance reading from the tip of a hot soldering iron to ground shall be less than 0.2 ohm (Simpson Model 260 meter, equivalent or better on the RX1 scale). Low voltage (less than 15 volts) soldering equipment need not be grounded if the isolation transformer contains a grounded electrostatic shield between its primary and secondary windings. Other electronic equipment or tools which come into contact with electronic components or assemblies shall be grounded (200 Ohms or less) when measured with a Simpson Model 260 meter, equivalent or better on the RX10 scale.

5.1.10 CHAIRS OR STOOLS

Chair or stool parts that could contact personnel, equipment, or tools where electronic components and assemblies are handled or tested shall have a surface resistivity of 10^7 ohms/square or less and shall be grounded through a 100,000 ohms minimum to 500,000 ohm maximum resistance when measured with a Simpson Model 260 meter, equivalent or better on the RX1000 scale.

5.1.11 GROUNDED WORK STATION

Handling and testing of electronic components and assemblies shall be performed at a grounded work station as shown in Figure 1.

5.2 PERSONNEL

Category 1 and 2 electronic components and assemblies shall only be handled, stored or tested in protected areas by personnel meeting or exceeding the requirements for that category as shown in Table 1.

5.2.1 WEARING APPAREL

5.2.1.1 SMOCKS, GLOVES, FINGER COTS, SHOES - Smocks, gloves or finger cots made of plastic, rubber or nylon shall not be worn. Cotton wearing apparel is acceptable as opposed to any synthetic material.

5.2.1.2 WRIST BRACELETS - Personnel handling electronic components and assemblies shall wear a wrist bracelet which is connected to the common ground through a 150,000 ohm minimum to 200,000 maximum resistance when measured with a Simpson Model 260 meter, equivalent or better on the RX1000 scale. Personnel shall not be connected directly to hard ground to help ensure that personnel safety requirements are met.

5.2.1.3 OUTER GARMENT

Personnel handling electric components or assemblies shall wear an outer garment (smock, etc) with a surface resistivity of less than 10^7 ohms/square when measured per ASTM Test Method D257 or equivalent or better.

5.2.2 HANDLING

5.2.2.1 GENERAL. Electronic components and assemblies shall be unpackaged, packaged, handled, worked on and stored only in protected areas (See 3.0.4).

5.2.2 Component body handling. Electronic components and assemblies shall be handled by their body/case and not by their leads.

5.2.2.3 Protective Covering. Each electronic component and assembly shall be covered, wrapped or bagged whenever they are not being tested or worked on. Materials used shall have a maximum surface resistivity of 10^{12} ohms/square when measured per ASTM Test Method D257 or equivalent or better. Covering, wrapping or bagging shall be accomplished in a manner not to induce penetration of the protective package by the electronic component or assembly. Note: This requirement shall not require repackaging or over-packaging of components or assemblies which are already adequately packaged and identified according to the intent of this document.

5.2.2.4 Power applied to leads. No power shall be applied to the electronic component or assembly test socket(s) while being inserted or otherwise connected.

5.3 PACKAGING AND STORAGE

Category 1 and 2 electronic components and assemblies shall be packaged and stored in protected areas of the facility meeting or exceeding the requirements for that category as shown in Table I.

5.3.1 External leads of packaged electronic components and assemblies.

Electronic components and assemblies received, shipped or stored shall be packed in a manner such that external leads are electrically connected to each other through a maximum resistivity of 10-12 ohms/square when measured per ASTM Test Method D257 or equivalent or better.

5.3.2 Marking of containers. Electronic components and assemblies received or to be shipped or stored shall have their associated container(s) marked or tagged with a legend of an attention-attracting color easily readable to normal or corrected vision at a visual inspection distance of three feet stating the appropriate category used: "CAUTION - ELECTROSTATIC SENSITIVE DEVICE: Category _____. Do not remove antistatic protection except when applying test voltage or for final assembly."

Purchase Orders to vendors supplying ESDS parts to Honeywell should reflect a requirement to mark containers in a manner which will make them readily identifiable as to their sensitivity.

5.3.3 Packing Material. Electronic components and assemblies shall be wrapped in material with a maximum surface resistivity of 10^5 ohms/square if packing material with surface resistivity of greater than 10^{12} ohms/square is used in packing. Measurement shall be per ASTM Test Method D257 or equivalent or better.

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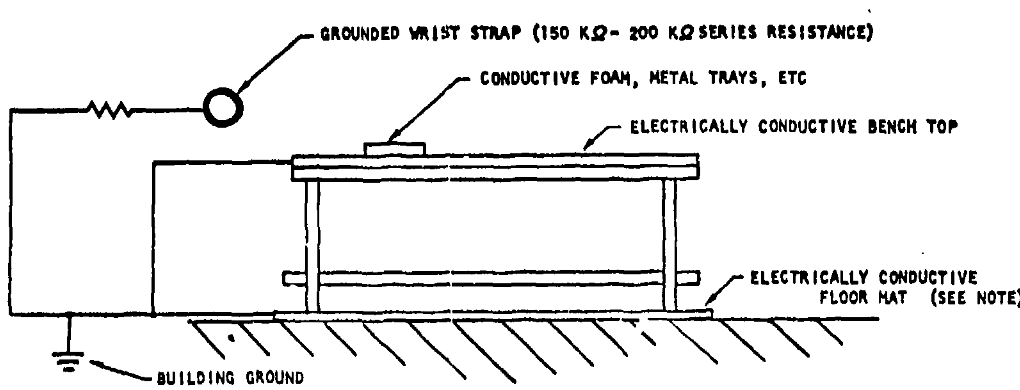

NOTE: THE ELECTRICALLY CONDUCTIVE FLOOR MAT SHALL BE OF SUCH SIZE AS TO ALLOW TEST PERSONNEL TO BE IN CONTACT WITH THE FLOOR MAT WHILE WORKING (STANDING or SITTING) AT THE BENCH

REQUIRED TEST STATION

(other approaches achieving the same results shall be acceptable)

6.0 GUIDELINES

6.1 GENERAL

The following guidelines, although not required to meet the intent of this document, are listed for guidance purposes.

6.2 MATERIALS

The following list of materials may be used to implement the requirements of this document.

Conductive Polyethylene film (Velostat #1701M or equivalent)
Conductive Polyethylene bag (Velostat #1798M or equivalent)
Conductive Foam Cushioning (Velofoam #7611M or equivalent)

6.3 TOOLS AND SPECIAL EQUIPMENT

The following list of tools and special equipment may be used to implement the requirements of this document.

Static Eliminator (TEC Cynostat DS-120 or equivalent)
Personnel Grounding Straps (Velostrap #6098M or equivalent); 150 K ohms resistance + 20 percent
Static Detection Meter (Velostat CMI-777M or equivalent)

6.4 SOURCES OF ESD PROTECTIVE ITEMS

The following manufacturers produce products that meet the requirements of items and materials noted in this document. The manufacturers noted are known sources of ESD protective items and are presented for information only and does not preclude the procurement from any manufacturer meeting the requirements of this document.

a. Customs Material, Inc.
Chelmsford, Massachusetts - 01824
(Straps, mats, films, foams, containers, and electrostatic detection meter)

b. Emerson & Cumming, Inc.
Canton, Massachusetts - 02021
Gardena, California - 90248
(Films, foams, and fabrics)

c. The Richmond Corp.
Redlands, California - 92373
(Films, Foams, Containers, Bags)

d. B. K. Sweeney Mfg. Co.
Denver, Colorado - 80216
(Electrostatic detection equipment)

e. Monroe Electronics, Inc.
Lyndonville, New York - 14098
(Electrostatic detection equipment)

f. 3 M
St. Paul, Minnesota - 55101
(Straps, mats, foams, containers, ionic blowers, and detection meters)

6.5 OPERATING PRECAUTIONS

The following operating instructions are shown to indicate minimum general operating guidelines.

6.5.1 RECEIVING DOCK

A) Personnel should not unnecessarily handle any device received which indicates it is a "ESDS" Device.

B) If counting is required, parts should not be removed from the vendor packing under any circumstances. If packing is not transparent counting should not be done.

C) Insure any warning or precaution marking remains on packaging as received.

D) Any questions or problems should be referred to Quality Engineering for resolution.

6.5.2 RECEIVING INSPECTION

A. Affix precaution label (HL-145) to each container.

B. Operator must wear a cotton smock whenever handling ESDS devices.

C. If the IPI calls for finger protection - cotton gloves must be worn.

D. Assure devices are in an approved container. Approved containers are those that short the devices' leads with wire, metal foil, or other conductive material such as conductive foam (Black Foam). Also acceptable are plastic trays specially treated with an antistatic spray. NOTE: Plastic rail carriers used for dual-in-line pakcages are not acceptable carriers. Conductive rail carriers are acceptable. If not properly packaged or if unsure of proper packaging consult Group Leader, Supervisor, or cognizant PQA Engineer before handling devices.

E. Inspection benches and seats must be of a conductive material and grounded to preclude the high static charge created by the sliding of the body on an insulated bench or seat.

F. The inspector must be grounded thru a high resistance groundstrap when handling and/or testing ESDS devices.

G. Place parts on a grounded conductive plate as soon as they are unpacked from their containers.

H. When testing is specified, all the test equipment contact pins must be grounded while the device is placed in the test socket.

I. Devices must be returned to proper containers after inspection and/or when being moved from one area to another.

J. Handle devices only when necessary and then by first grasping the body before touching any of the individual leads. Ceramic packages with brazed leads require extra careful handling to avoid breaking off the leads.

K. Materials prone to static charge accumulation, such as plastic, rubber, and silk, or synthetic cloth should not come in contact with ESDS devices.

6.5.3 STOCK AREAS

a) Personnel should not unnecessarily handle any device received which indicates it is a "ESDS" device.

b) When parts are issued to Assembly they should be packed in the same manner as they were received.

c) If parts must be handled in order to issue partials, personnel must be properly grounded and follow precautions in this document.

6.5.4 ASSEMBLY

a) Perform all assembly operations involving ESDS devices on a grounded conductive plate.

b) Chair seats in the assembly area must be of a conductive material and must be grounded.

c) Smocks made of nylon or other synthetic materials shall not be worn. Operator must wear cotton smock whenever handling ESDS devices.

d) Maintain the short placed on the devices' leads and/or keep devices in the specially treated plastic containers until time of assembly.

e) The assembler must ground himself on a conductive plate before handling a device. P.C. Board bench clamps or vises must also be grounded.

f) ESDS devices must be handled by either the ceramic body (flatpacks and dual-in-lines) or the metal cans (TO-5, TO-99, or other canned devices).

g) All electrical assembly equipment, e.g., soldering irons and tips, insulation strippers, heat guns, etc. must be grounded. All solder pots, reflow soldering equipment, and desoldering tools must also be grounded.

h) When testing is specified, all the test equipment contact pins must be grounded while the device is placed in the test socket. This action avoids the possibility of a charged test set discharging into the device as it is placed in the test socket.

i) Prevent the accumulation of solder flux between adjacent pins which may cause leakage paths. MOS device operation depends upon the high impedance between certain circuit elements and ground. Solder fluxes in the presence of a humid atmosphere can be very conductive.

6.5.4 TEST

a) Ground all test equipment.

b) Dielectric strength or insulation resistance tests are not recommended for equipment containing ESDS devices.

c) Continuity tests must be performed only when authorized by the cognizant engineer. Certain MOS devices have built-in protective diodes which cannot sustain more than 10 MA current. A Simpson 260 VOM is capable of producing as high as 300 MA for short periods of time on the X1 ohmic scale.

d) Perform all operations on a grounded conductive plate on the test bench. Periodic checks of assembly, rework, and test stations must be made to assure adequate grounding. Sources of static discharge and floating 60 cycle ac resulting from faulty ground connections must be eliminated.

APPENDIX E

XM587E2/XM724 FUZE INITIAL PRODUCTION FACILITY DATA

The following assumptions were made:

- Contract award will be for the production of 225,000 fuzes and required non recurring costs.
- Production schedule deliveries would begin in 15th month and continue through 24th month (see figure E-1).
- Acceptance of initial tooling, facilities, and equipment will be on the basis of passing first article acceptance sample tests and meeting production schedule.
- An additional contract award for the initial production facility required for the first production buy and establishment of a mobilization base capable of 100,000 fuzes per month on a 1-8-5 production basis will be awarded simultaneously with the primary production contract award to ensure production deliveries.
- The automated mobilization base facility will be completed in 24 months after award.
- The automated equipment will be accepted per specifications submitted under Contract DAAG39-76-C-0048.
- As automated equipment is accepted for production, it may be integrated into the production process without requiring additional first article acceptance sample testing.
- Cost data are valid only if the total composite program is contracted.
- M739 fuze machine 1, 2, 3, 4, and 5 will be used to produce M739 and XM587E2/XM724 fuze S&A module subassemblies until XM587E2/XM724 fuze S&A module machines are accepted and available for production.

Projected delivery schedules on the M739 fuze S&A module show no conflicts in meeting deliveries.

- A difference in module pin length in the S&A module assembly will be resolved by engineering change order if bowl feeding cannot handle both lengths (M739 fuze machine 4).

- Constant 1976 dollars were used.

- All production (i.e., assembly) on the first production schedule will be done at the New Brighton, Minnesota plant except for the wave soldering machine (located at the Hopkins, Minnesota plant) which will be used to wave solder the E-head printed wiring board assemblies. The electronics will be assembled to the printed wiring board assemblies with Honeywell-owned insertion equipment located in the Hopkins, Minnesota plant.

- The facility has no restriction on shift, hour, and day usage for the first production delivery schedule.

- Printed wiring boards will be redesigned for auto insertion.

- The following drawing packages were used as the baseline for this estimate:

    - The S&A module assembly, rear fitting assembly, and fuze data lists are dated 17 December 1975.

    - Incorporation of all engineering change proposals (ECPs) from Contracts DAAG39-76-C-0048 and DAAG39-77-C-0056.

- The power supply design includes a detonator firing lead internal to the power supply. No provision has been made in this estimate for accommodating an external firing lead assembly. If the external lead design is retained, the estimated cost increase for the tooling will be $36,296 at price. This tooling will fabricate the lead and assemble it to the power supply.

- The requirement of drawing 11711274 (shock requirement for electronic components) will be met by using qualified vendors.

- Automated assembly machine manuals will be per Honeywell format.
- Machine documentation will be per Honeywell format. (HDL will have concept approval from three-dimensional sketches prior to fabrication).
- Gage and calibration master documentation will be per Honeywell format. (HDL approval of design required prior to fabrication).
- A process manual (description of manufacture) is not required.
- Acceptance of all equipment will be accomplished at the New Brighton, Minnesota plant. No transportation or installation costs to another location are included.
- The automated assembly line estimate is based on data submitted in the final report of Contract DAAG39-76-C-0048.
- All production assembly subsequent to the first scheduled deliveries (225,000 units) will be done at the New Brighton, Minnesota plant.

A cost summary is provided in table E-I. Detailed cost data are presented in tables E-II through E-XVIII.

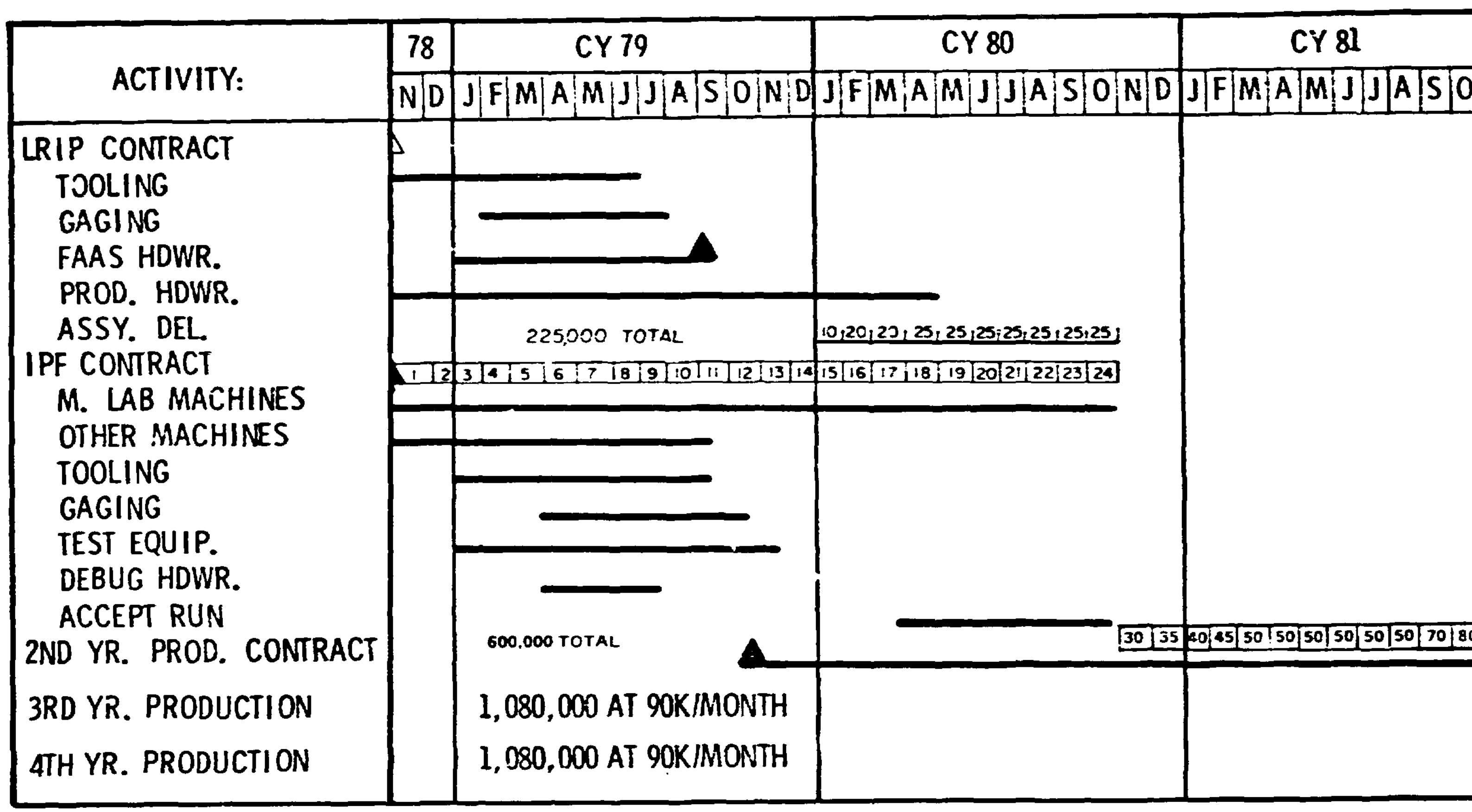

Figure E-1. Composite program production schedule

TABLE E-I. COMPOSITE PROGRAM COST SUMMARY

DESCRIPTION	NON-RECURRING 225K PROD.	IPF 100K PER MONTH
1. MACHINES (MACHINE LAB)		2,746,831
2. MACHINES (OTHER)		557,282
3. TEST EQUIPMENT		783,240
4. DATA ITEMS	57,414	172,242
5. SUPPORT	317,388	714,308
6. PROD. LINE SHAKEDOWN	153,783	551,951
. Debug	39,769	290,622
. Accept	114,014	261,329
7. VENDOR TOOLING	258,505	
8. MFG. TOOLING	269,176	
9. ASSEMBLY TOOLING	472,672	166,030
10. MATERIAL HANDLING	98,512	
11. GAGES	235,407	9,257
12. GOVERNMENT FURNISHED MAT'L		
. Total LBM	1,862,857	5,701,141
. Total Cost (19% G&A)	2,216,800	6,784,358
. Subtotal Price(10% fee)	2,438,480	7,462,794
. Less G&A & Fee (Table except items 1&7)		120,598
. Subtotal	2,438,480	7,342,196
. With contingency	2,560,404	7,709,306
. Area Prep	300,000	150,000
TOTAL	2,860,404	7,859,306

TABLE E-II. MACHINE COSTS (HONEYWELL MACHINE DEVELOPMENT LABORATORY)

MACHINE NAME	IDENT.	QTY.	1ST HRS.	1ST $	2ND HRS.	2ND $	TOTAL
1. S&A MODULE LOWER SUBASSEMBLY	S 1	1					
M/L (Machine Lab)			1000	$ 32,370			
T/D (Tool Design)			496	8,085			
Maint. (Maintenance)			671	9,334			
T/R (Tool Room)			2177	41,341			
Mat'l (Material)				30,357			
TOTAL				$121,487			$ 121,487
2. S&A MODULE LOWER SUBASSEMBLY	S 2	1					
M/L			906	$ 29,327			
T/D			639	10,416			
Maint.			669	9,306			
T/R			2190	41,588			
Mat'l				33,266			
TOTAL				$123,903			$ 123,903
3. LOWER PLATE & SHAFT ASSEMBLY	S 3	1					
M/L			851	$ 27,547			
T/D			421	6,862			
Maint.			611	8,499			
T/R			2128	40,411			
Mat'l				28,942			
TOTAL				$112,261			$ 112,261

TABLE E-II. MACHINE COSTS (HONEYWELL MACHINE DEVELOPMENT LABORATORY) (CONTINUED)

MACHINE NAME	IDENT.	QTY.	1ST HRS.	1ST $	2ND HRS.	2ND $	TOTAL
4. SPRING LOCK PIN	S 4	1					
M/L			94	$ 3,043			
T/D			67	1,092			
Maint.			65	904			
T/R			473	8,982			
Mat'l				12,043			
TOTAL				$ 26,064			$ 26,064
5. S&A SUBASSEMBLY	S 5	1					
M/L			1415	$ 45,806			
T/D			981	15,990			
Maint.			827	11,504			
T/R			3136	59,553			
Mat'l				41,373			
TOTAL				$174,226			$ 174,226
6. ROTOR ASSEMBLY	S 6	1					
M/L			1171	$ 37,905			
T/D			725	11,818			
Maint.			778	10,822			
T/R			2786	52,906			
Mat'l				36,180			
TOTAL				$149,631			$ 149,631

TABLE E-II. MACHINE COSTS (HONEYWELL MACHINE DEVELOPMENT LABORATORY) (CONTINUED)

MACHINE NAME	IDENT.	QTY.	1ST HRS.	1ST $	2ND HRS.	2ND $	TOTAL
7. SPRING SPIN LOCK	S 7	1					
M/L			94	$ 3,043			
T/D			67	1,092			
Maint.			65	904			
T/R			473	8,982			
Mat'l				12,974			
TOTAL				$ 26,995			$ 26,995
8. S&A SUBASSEMBLY	S 8	1					
M/L			1565	$ 50,659			
T/D			866	14,116			
Maint.			879	12,227			
T/R			3335	63,332			
Mat'l				33,339			
TOTAL				$173,673			$ 173,673
9. S&A MODULE ARM CHECKS	S 9	2					
M/L			1509	$ 48,846	1068	$ 34,571	
T/D			742	12,095	176	2,869	
Maint.			752	10,460	752	10,640	
T/R			3150	59,819	3150	59,819	
Mat'l				28,983		28,983	
TOTAL				$160,203		$136,882	$ 297,085

TABLE E-II. MACHINE COSTS (HONEYWELL MACHINE DEVELOPMENT LABORATORY) (CONTINUED)

MACHINE NAME	IDENT.	QTY.	1ST HRS.	1ST $	2ND HRS.	2ND $	TOTAL
10. S&A MODULE	S10	2					
M/L			1300	$ 42,081	901	$ 29,165	
T/D			777	12,665	284	4,629	
Maint.			719	10,001	719	10,001	
T/R			2830	53,741	2830	53,742	
Mat'l				29,308		29,308	
TOTAL				$147,796		$126,845	$ 274,641
11. SPRING SETBACK	S11	1					
M/L			94	$ 3,043			
T/D			67	1,092			
Maint.			65	204			
T/R			473	8,982			
Mat'l				12,362			
TOTAL				$ 25,683			$ 25,683
12. CUP/COVER ASSEMBLY	E 1	2					
M/L			1197	$ 38,747	775	$ 25,087	
T/D			726	11,834	263	4,287	
Maint.			875	12,171	875	12,171	
T/R			2913	55,318	2913	55,318	
Mat'l				47,602		47,602	
TOTAL				$165,672		$144,465	$ 310,137

TABLE E-II. MACHINE COSTS (HONEYWELL MACHINE DEVELOPMENT LABORATORY) (CONTINUED)

MACHINE NAME	IDENT.	QTY.	1ST HRS.	1ST $	2ND HRS.	2ND $	TOTAL
13. NOSE PLUG ASSEMBLY	E 2	2					
M/L			949	$ 30,719	613	$ 19,843	
T/D			586	9,552	198	3,227	
Maint.			696	9,681	696	9,681	
T/R			2300	43,677	2300	43,677	
Mat'l				40,041		40,041	
TOTAL				$133,670		$116,469	$ 250,139
14. STAKE ELECT. NOSE CONE ASSY.	E 3	1					
M/L			1163	$ 37,646			
T/D			706	11,508			
Maint.			733	10,196			
T/R			2858	54,273			
Mat'l				25,244			
TOTAL				$138,867			$ 138,867

TABLE E-II. MACHINE COSTS (HONEYWELL MACHINE DEVELOPMENT LABORATORY) (CONTINUED)

MACHINE NAME	IDENT.	QTY.	1ST HRS.	1ST $	2ND HRS.	2ND $	TOTAL
15. DET. BLOCK ASSY.	F 1	1					
M/L			663	$ 21,461			
T/D			411	6,699			
Maint.			528	7,344			
T/R			1604	30,460			
Mat'l				26,057			
TOTAL				$ 92,021			$ 92,021
16. DET. BLOCK ASSY.	F 2	1					
M/L			1222	$ 39,556			
T/D			876	14,279			
Maint.			838	11,657			
T/R			3122	59,287			
Mat'l				41,593			
TOTAL				$166,372			$ 166,372
17. REAR FITTING	F 3	1					
M/L			1055	$ 34,150			
T/D			652	10,628			
Maint.			713	9,918			
T/R			2660	50,513			
Mat'l				29,309			
TOTAL				$134,518			$ 134,518

TABLE E-II. MACHINE COSTS (HONEYWELL MACHINE DEVELOPMENT LABORATORY) (CONCLUDED)

MACHINE NAME	IDENT.	QTY.	1ST HRS.	1ST $	2ND HRS.	2ND $	TOTAL
18. REAR FITTING ASSY.	F 4	1					
M/L			1265	$ 40,948			
T/D			729	11,883			
Maint.			762	10,599			
T/R			3257	61,850			
Mat'l				23,183			
TOTAL				$148,463			$ 148,463
TOTAL COST							$2,746,831

TABLE E-III. MACHINE COSTS (OTHER - PURCHASED)

MACHINE NAME	FLOW DIAGRAM IDENT.	QTY.	UNIT COST	TOTAL COST
1. CRIMP E-HEAD TO RF ASSY	F5	1	$24,640	$ 24,640
2. SEQUENCER	AS1,AS2	2	45,244	90,488
3. AXIAL LEAD INSERTION MACHINE	AS3,AS4	2	60,661	121,322
4. TRANSISTOR INSERTION MACHINE	AS5	1	54,584	54,584
5. DIP INSERTION MACHINE	AS6	1	61,016	61,016
6. WAVE SOLDER MACHINE		1	25,000	25,000
7. POTTING SYSTEM FOR E-HEAD	P1	1	82,225	82,225
8. RONCI ENAMELING MACHINE	S&A	1	7,000	7,000
9. ULTRASONIC CLEANER	S&A	1	3,500	3,500
10. PREHEAT & DRYING OVEN	S&A	1	2,500	2,500
11. VENTILATED TUMBLING BARREL	S&A	1	2,000	2,000
12. CONVEYORIZE CURING OVEN	S&A	1	5,000	5,000
13. FLUROSCOPE	FUZE	1	52,482	52,482
Subtotal				$531,758
Mat'l Acq. Rate 4.8%				1.048
TOTAL				$557,282

TABLE E-IV. TEST EQUIPMENT COSTS

	QTY.	M&TE ENG. HRS.	M&TE TECH. HRS.	PROCESS LAB HRS.	QUAL ENG. HRS.	TOOL MAKE HRS.	ELEC-TRICIAN HRS.	CALIB. LAB HRS.	DRAFT-ING HRS.	MAT'L $	TOTAL
E-HEAD TESTERS (T1 & T2)	16	3,468	6,606	4,208	400	3,424	832	448	984	$291,093	
LB Rate/		$22.08	$18.10	$23.42	$22.08	$18.99	$13.91	$18.10	$18.87	4.8%	
Mat'l Acq.		$76,573	$119,569	$98,551	$8,832	$65,022	$11,573	$8,109	$18,568	$305,065	$711,862
FUZE SET & INTER. (T3)	2	598	596	332	34	300	60	20	250	26,000	
LB RATE/ MAT'L ACQ.		$22.08	$18.10	$23.42	$22.08	$18.99	$13.91	$18.10	$18.87	4.8%	
Subtotal		$13,204	$10,787	$7,776	$751	$5,697	$835	$362	$4,718	$27,248	$ 71,368
TOTALS		$89,777	$130,356	$106,327	$9,583	$70,719	$12,408	$8,471	$23,286	$332,313	$783,240

TABLE E-V. DATA ITEM COSTS

PRODUCTION ENGINEERS

CATEGORY	NO. MONTHS	M.M. SUPPORT	RATE	FACTORY COST
225K PRODUCTION	12	14	4101	$ 57,414
IPF	24	42	4101	172,242

225K PRODUCTION: 2 men first 2 months; 1 man next 10 months.

IPF: 1 man first 6 months; 2 men next 18 months.

TABLE E-VI. NONRECURRING SUPPORT COSTS

CATEGORY	225K PRODUCTION		IPF 100K/MO.	
	MM	FACTORY COST	MM	FACTORY COST
PROD. ENG. MFG.	3	$ 12,303		
PROD. ENG. ASSY.	36	147,636	83	$340,383
DEV. ENG. II	7	36,148	14	72,296
DRAFTING	1	3,168	3	9,504
RELIABILITY			8.4	43,378
QUALITY ENG.	17	64,345	40	151,400
ASSY. INSPECTION	8	19,504	23.8	58,022
REC. INSPECTION	3.3	8,045		
M&TE ENG.	0.6	2,271	1	3,785
CAL. TECH	0.8	2,481	1.2	3,721
EVAL. TECH	4	12,180	6.2	18,879
EVAL. ENG.	1.5	7,785	2.2	11,41[illegible]
M&TE TECH	0.5	1,522	0.5	1,5[illegible]
TOTAL FACTORY COST		$317,388		$714,3[illegible]

TABLE E-VII. DEBUG AND ACCEPTANCE HARDWARE COSTS
(NONRECURRING PRODUCTION OF 225,000 UNITS)

MACHINE LINE/HANDLINE			PARTS QTY.		MAT'L COST		LABOR COST	
			DEBUG	ACCEPT	DEBUG	ACCEPT	DEBUG	ACCEPT
S1	S&A MODULE LOWER SUBASSEMBLY(M739 #4)						$ 540	$ 216
	11720304	Pin Module	20,000	8,000	$ 63	$ 25		
	11720322	Shaft Spin Lock	10,000	4,000	46	18		
	11720318	Spacer, Gear Plate	5,000	2,000			775	310
S2	S&A MODULE LOWER SUBASSEMBLY(M739 #4)							
	11720335	Plate, Bottom	7,000	2,000			2,542	726
	11720324	Pin Rotor Lock	5,000	2,000	38	15	201	80
	11720323	Disk Lock Pin	5,000	2,000	23	9		
S3	LOWER PLATE & SHAFT ASSEMBLY(M739 #1)						155	62
	11720321	Plate L. Gear	5,000	2,000	939	376	5,631	2,252
	11720320	Shaft, Pallet	5,000	2,000	107	43	201	80
S4	SPRING LOCK PIN (M739 #3)							
	11720325	Lock Pin Spring	5,000	2,000	330	68	560	112
S5	S&A SUBASSEMBLY						2,113	4,226
	11711728	Gear & Pinion	500	1,000	45	89	241	482
	11720308	Wheel & Pinion	500	1,000	43	86	241	482
	11720303	U. Gear Plate	500	1,000	20	40	329	658
	11720328	Spin Lock	500	1,000	11	21	40	80
	11720309	Pallet	500	1,000	2	3	207	413
	11720319	LB & Shaft	500	1,000	PARTS FROM S3		16	
	11720305	R. Assembly	500	1,000	PARTS FROM S6		16	

TABLE E-VII. DEBUG AND ACCEPTANCE HARDWARE COSTS (NONRECURRING PRODUCTION OF 225,000 UNITS) (CONTINUED)

MACHINE LINE/HANDLINE		PARTS QTY.		MAT'L COST		LABOR COST	
		DEBUG	ACCEPT	DEBUG	ACCEPT	DEBUG	ACCEPT
S6	ROTOR ASSEMBLY (M739 #2)					$ 155	$ 62
11720306	Rotor Body	5,000	2,000	$ 95	$ 38	1,481	592
11720330	Rotor Gear	5,000	2,000	67	27	979	392
11720329	Rotor Shaft	5,000	2,000	89	36	201	80
S7	SPRING SPIN LOCK (M739 #5)						
11720327	Spin Lock Spring	1,000	2,000			56	113
S8	S&A SUBASSEMBLY					430	858
11720310	Lead (Live)		1,000		257		
11720310A	Lead (Inert)	500		28			
11720302	Can	500	1,000			268	535
S9	ARM CHECK					1,057	2,113
S10	S&A MODULE					294	594
11720317	Disk Setback	500	1,000	2	4		
11720333	Setback Pin	500	1,000	8	16		
S11	SPRING SETBACK						
11720334	Spring	500	1,000			28	56

TABLE E-VII. DEBUG AND ACCEPTANCE HARDWARE COSTS
(NONRECURRING PRODUCTION OF 225,000 UNITS) (CONTINUED)

MACHINE LINE/HANDLINE			PARTS QTY.		MAT'L COST		LABOR COST	
			DEBUG	ACCEPT	DEBUG	ACCEPT	DEBUG	ACCEPT
F1	DETONATOR BLOCK ASSEMBLY						$ 110	$ 220
	11720298	Det Block	500	1,000	$ 556	$1,112		
	NS27183-4	Washer	500	1,000	1	2		
	11720214	GRD Clip	500	1,000	3	7		
F2	DETONATOR BLOCK ASSEMBLY						440	880
	11722405	Det-Inert	500	1,000	38			
	28107993	Shorting Clip	500	1,000	22	44		
	11720297	Contact	500	1,000	8	17		
	11720299	Insulator	500	1,000	7	15		
	11718234	Det Clip	500	1,000	18	36		
F3	REAR FITTING						330	660
	11720258	Lead-Live		1,000		168		
	11720258	Lead Inert	500		28			
	MS51923-138	Pin Spring	500	1,000	3	7		
	11722622	Sleeve	500	1,000	1,533	3,066		
F4	REAR FITTING ASSEMBLY					522		
	11720296	Spring Bias	500	1,000	20	40		
F5	CRIMPING STATION		2,000	1,000			176	88

TABLE E-VII. DEBUG AND ACCEPTANCE HARDWARE COSTS (NONRECURRING PRODUCTION OF 225,000 UNITS) (CONTINUED)

MACHINE LINE/HANDLINE	PARTS QTY.		MAT'L COST		LABOR COST	
	DEBUG	ACCEPT	DEBUG	ACCEPT	DEBUG	ACCEPT
E1 CUF & COVER ASSEMBLY					$ 925	$1,850
11711410 Cup	500	1,000	$ 345	$ 689		
11711417-2 Contact Pad	1,000	2,000	9	19		
11711418 Contact Coil	1,500	3,000	16	31		
11711409 Cover	500	1,000	26	45		
E2 NOSE PLUG ASSEMBLY					330	610
11711407 Nose Plug	500	1,000	92	184		
11711417-1 Pad Contact	500	1,000	15	30		
11711450-1 Setting Ring	500	1,000	628	1,256	330	610
11711450-2 Setting Ring	500	1,000	628	1,256	330	610
E3 STAKE ELECTRONIC NOSE CONE ASSEMBLY					1,761	3,522
11711430 E-Head (Unpotted)	500	1,000	4,205	8,410		
11711408 Nose Cone	500	1,000	1,216	2,431		
MS9386-015 O'Ring	500	1,000	2	3		
11711419 Strip, Lead Frame		400		63		
11711411 PWB #2		400		985		
11711610 Interface Circuit		400		9,591		
11711404-1 Capacitor		400		178		
11711405-3 Resistor		400		104		
11711405-6 Resistor		400		104		
11711234 Zenor Diode		400		252		
11711242 Zenor Diode		400		252		
11711256 MOS Scaler		400		3,974		
10990466 MNOS Counter Memory		400		1,861		
11711412 PWB #1		400		985		
11711404-2 Capacitor		400		157		
11711405-9 Resistor		800		208		
11711406 Diode		1,600		252		
continued..........						

TABLE E-VII. DEBUG AND ACCEPTANCE HARDWARE COSTS (NONRECURRING PRODUCTION OF 225,000 UNITS) (CONTINUED)

MACHINE LINE/HANDLINE	PARTS QTY.		MAT'L COST		LABOR COST	
	DEBUG	ACCEPT	DEBUG	ACCEPT	DEBUG	ACCEPT
E3 STAKE ELECTRONIC NOSE CONE ASSEMBLY ....continued						
11711424 Transistor		800		$ 335		
11711625 Precision Oscillator		400		9,591		
11711240 Capacitor-Ceramic		400		419		
11718418 Impact Switch		400		650		
NAS 549-2 Washer		400		23		
11711448 Transformer		400		452		
E4 TRIM FILL TUBES						$ 285
	2,000	1,800			$1,917	586
AS1 SEQUENCER		2,000		2,070		380
11711404-2 Capacitor						
11711405-9 Resistor						
11711405-9 Resistor						
11711240 Capacitor						
11711406 Diode						
AS2 SEQUENCER		2,000		1,778		238
11711404-1 Capacitor						
11711234 Zener Diode						
11711242 Zener Diode						
11711405-3 Fixed Resistor						
11711405-6 Fixed Resistor						
AS3 AXIAL LEAD INSERTION MACHINE		2,000		1,970		298
11711412 PWB #1						

TABLE E-VII. DEBUG AND ACCEPTANCE HARDWARE COSTS (NONRECURRING PRODUCTION OF 225,000 UNITS) (CONTINUED)

MACHINE LINE/HANDLINE		PARTS QTY		MAT'L COST		LABOR COST	
		DEBUG	ACCEPT	DEBUG	ACCEPT	DEBUG	ACCEPT
AS4	AXIAL LEAD INSERTION MACHINE		2,000		$ 1,970		$ 155
	11711411 PWB #2						
AS5	TRANSISTOR INSERTION MACHINE		2,000		336		88
	11711424 Transistor						
AS6	DIP INSERTION MACHINE		500		17,786		73
	10990466 MNOS Counter Memory						
	11711256 Scaler Logic & Overhead Safety Circuit						
	WAVE SOLDER		1,000			$ 528	176
T1	ELECT. TEST ELECTRONICS ASSEMBLY		1,000				383
T2	POST POT ELECT. TEST OF E-HEAD		1,000				383
T3	ELECT. TEST SET & INTEROGATE		400				141
	PUNCH PRESS (Separate Boards)		500				38
	PUNCH PRESS (Separate Boards)		500				38
P1	POTTING		3,600		986		1,775
	BENCH OPERATION						
	Bench #1		1,000				925
	Bench #2		1,000				771
	Bench #3		1,000		63		2,097
	Bench #4	4,000	1,000	1,228	307	1,232	308

TABLE E-VII. DEBUG AND ACCEPTANCE HARDWARE COSTS
(NONRECURRING PRODUCTION OF 225,000 UNITS) (CONCLUDED)

MACHINE LINE/HANDLINE	PARTS QTY.		MAT'L COST		LABOR COST	
	DEBUG	ACCEPT	DEBUG	ACCEPT	DEBUG	ACCEPT
TOUCH UP: PWB #1		1,000				$ 925
PWB #2		1,000				925
TROUBLESHOOT						139
Total with 4.8% Material Acquisition			$12,603	$78,263	$27,166	35,751

	DEBUG		ACCEPT		TOTAL
TOTALS	$39,769	+	$114,014	=	$\boxed{\$153,783}$

NOTE: Labor costs include piece part manufacturing costs and labor to debug and run acceptance tests of the machines and equipment.

TABLE E-VIII. DEBUG AND ACCEPTANCE HARDWARE COSTS (IPF)

MACHINE LINE	PARTS QTY		MAT'L COST		LABOR COST	
	DEBUG	ACCEPT	DEBUG	ACCEPT	DEBUG	ACCEPT
S1 S&A MODULE LOWER SUBASSEMBLY						$ 854
11720304 Pin Module	100,000	43,200	$ 313	$ 135		
11720322 Shaft Spin Lock	50,000	21,600	228	98		
11720318 Spacer, Gear Plate	25,000	10,800	518	215	$3,511	1,458
S2 S&A MODULE LOWER SUBASSEMBLY						722
11720335 Plate, Bottom	19,600	8,250	391	165	672	2,831
11720324 Pin Rotor Lock	19,600	8,250	147	62	786	331
11720323 Disk Lock Pin	13,200		61			
S3 LOWER PLATE & SHAFT ASSEMBLY						497
11720321 Plate L. Gear	27,800	12,600	5,193	2,335	31,307	14,189
11720320 Shaft, Pallet	27,800	12,600	593	269	1,115	506
S4 SPRING LOCK PIN						360
11720325 Lock Pin Spring	17,600	8,250	66	34	989	464
S5 S&A SUBASSEMBLY						1,089
11711728 Gear & Pinion	15,200	6,800	1,365	611	7,318	3,274
11720308 Wheel & Pinion	15,200	6,800	1,314	588	7,318	3,274
11720303 U. Gear Plate	15,200	6,800	621	278	9,996	4,772
11720328 Spin Lock	28,400	13,600	599	287	2,279	1,091
11720309 Pallet	15,200	6,800	51	23	6,274	2,807
11720319 LP & Shaft	PARTS FROM S3				604	
11720305 R. Assembly	PARTS FROM S6				407	
11720327 Spring SP/LK	PARTS FROM S7					

TABLE E-VIII. DEBUG AND ACCEPTANCE HARDWARE COSTS (IPF) (CONTINUED)

MACHINE LINE	PARTS QTY		MAT'L COST		LABOR COST	
	DEBUG	ACCEPT	DEBUG	ACCEPT	DEBUG	ACCEPT
S6 ROTOR ASSEMBLY						$ 722
11720306 Rotor Body	19,600	8,250	$ 371	$ 156	$5,806	2,444
11720330 Rotor Gear	19,600	8,250	263	111	3,839	1,616
11720329 Rotor Shaft	19,600	8,250	349	147	786	331
S7 SPRING SPIN LOCK						597
11720327 Spin Lock Spring	26,400	13,600	54	27	1,484	765
S8 S&A SUBASSEMBLY						561
11720310 Lead (Live)		5,100		1,309		
11720310A Lead (Inert)	10.000		545			
11720302 Can	12,800	5,100	865	345	768	306
S9 ARM CHECK	PARTS FROM S8					1,796
S10 S&A MODULE						1,585
11720317 Disk Setback	6,400	4,500	25	18		
11720333 Setback Pin	6,400	4,500	100	70		
S11 SPRING SETBACK						198
11720334 Spring	4,400	4,500	7	8	607	253

TABLE E-VIII. DEBUG AND ACCEPTANCE HARDWARE COSTS (IPF) (CONTINUED)

MACHINE LINE	PARTS QTY DEBUG	PARTS QTY ACCEPT	MAT'L COST DEBUG	MAT'L COST ACCEPT	LABOR COST DEBUG	LABOR COST ACCEPT
F1 DETONATOR BLOCK ASSEMBLY						$ 538
11720298 Det Block	15,200	6,800	$16,909	$ 7,565		
MS27183-4 Washer	15,200	6,800	29	13		
11720214 GRD Clip	15,200	6,800	105	47		
F2 DETONATOR BLOCK ASSEMBLY						494
11722405 Det-Inert	10,000		766			
28107993 Shorting Clip	8,800	5,100	390	226		
11720297 Contact	10,800	5,100	181	86		
11720299 Insulator	10,800	5,100	161	76		
11718234 Det. Clip	10,800	5,100	387	183		
F3 REAR FITTING						387
11720258 Lead-Live		4,000		671		
11720258 Lead Inert	4,000		219			
MS51923-138 Pin Spring	10,800	4,000	75	28		
11722622 Sleeve	4,000	4,000	12,266	12,266		
F4 REAR FITTING ASSEMBLY					$4,590	528
11720296 Spring Bias	4,400	3,000	172	117		

TABLE E-VIII. DEBUG AND ACCEPTANCE HARDWARE COSTS (IPF) (CONTINUED)

MACHINE LINE	PARTS QTY		MAT'L COST		LABOR COST	
	DEBUG	ACCEPT	DEBUG	ACCEPT	DEBUG	ACCEPT
E1 CUP & COVER ASSEMBLY						$ 563
11711410 Cup	10,800	4,000	$ 7,445	$ 2,757		
11711417-2 Contact Pad	19,600	8,000	364	148		
11711418 Contact Coil	28,400	12,000	893	377		
11711409 Cover	10,800	4,000	457	183		
E2 NOSE PLUG ASSEMBLY						563
11711407 Nose Plug	10,800	4,000	1,992	738		
11711417-2 Pad Contact	10,800	4,000	401	148		
11711450-1 Setting Ring	21,600	8,000	16,336	10,050		
11711450-2 Setting Ring	21,600	8,000	16,336	10,050		
E3 STAKE ELECTRONIC NOSE CONE ASSEMBLY						845
11711430 E-Head (Unpotted)	4,400	3,200	37,004	26,912		
11711408 Nose Cone	4,400	3,600	10,698	8,753		
MS9386-015 O'Ring	6,400	3,600	22	12		
11711419 Strip, Lead Frame		400		63		
11711411 PWB #2		400		985		
11711610 Interface Circuit		400		9,591		
11711404-1 Capacitor		400		178		
11711405-3 Resistor		400		104		
11711405-6 Resistor		400		104		
11711234 Zenor Diode		400		252		
11711242 Zenor Diode		400		252		
11711256 MOS Scaler		400		3,974		
10990466 MNOS Counter Memory		400		1,861		
11711412 PWB #1		400		985		
11711404-2 Capacitor		400		157		
11711405-9 Resistor		800		208		
11711406 Diode		1,600		252		

continued......

TABLE E-VIII. DEBUG AND ACCEPTANCE HARDWARE COSTS (IPF) (CONTINUED)

MACHINE LINE	PARTS QTY		MAT'L COST		LABOR COST	
	DEBUG	ACCEPT	DEBUG	ACCEPT	DEBUG	ACCEPT
E3 STAKE ELECTRONIC NOSE CONE ASSEMBLY ....continued						
11711424 Transistor		800		$ 335		
11711625 Precision Oscillator		400		9,591		
11711240 Capacitor-Ceramic		400		419		
11718418 Impact Switch		400		650		
NAS 549-2 Washer		400		23		
11711448 Transformer		400		452		
AS1 SEQUENCER		4,000		4,140		760
11711404-2 Capacitor						
11711405-9 Resistor						
11711405-9 Resistor						
11711240 Capacitor						
11711406 Diode						
AS2 SEQUENCER		4,000		3,556		475
11711404-1 Capacitor						
11711234 Zener Diode						
11711242 Zener Diode						
11711405-3 Fixed Resistor						
11711405-6 Fixed Resistor						
AS3 AXIAL LEAD INSERTION MACHINE		4,000		3,940		496
11711412 PWB #1						

TABLE E-VIII. DEBUG AND ACCEPTANCE HARDWARE COSTS (IPF) (CONTINUED)

MACHINE LINE	PARTS QTY		MAT'L COST		LABOR COST	
	DEBUG	ACCEPT	DEBUG	ACCEPT	DEBUG	ACCEPT
AS4 AXIAL LEAD INSERTION MACHINE		4,000		$3,940		$ 309
11711411 PWB #2						
AS5 TRANSISTOR INSERTION MACHINE		4,000		672		176
11711424 Transistor						
AS6 DIP INSERTION MACHINE		1,000		25,571		145
10990466 MNOS Counter Memory 11711256 Scaler Logic & Overhead Safety Circuit						
WAVE SOLDER	6,000	2,000			$1,056	352
T1 ELECT. TEST ELECTRONICS ASSEMBLY		1,000				766
T2 POST POT ELECT. TEST OF E-HEAD		1,000				766
T3 ELECT. TEST SET & INTEROGATE		400				141
PUNCH PRESS (Separate Boards)		1,000				75
PUNCH PRESS (Separate Boards)		1,000				75
P1 POTTING	4,000		$1,096		1,972	

TABLE E-VIII. DEBUG AND ACCEPTANCE HARDWARE COSTS (IPF) (CONCLUDED)

MACHINE LINE	PARTS QTY		MAT'L COST		LABOR COST	
	DEBUG	ACCEPT	DEBUG	ACCEPT	DEBUG	ACCEPT
Subtotal (With 4.8% Material Acquisition)			$138,743	$160,952	$93,484	$57,795

TABLE E-IX. DEBUG AND ACCEPTANCE HARDWARE COSTS (ADDITIONAL COSTS REQUIRED DUE TO DUPLICATION OF MACHINES S9, S10, E1, AND E2)

MACHINE LINE	PARTS QTY		MAT'L COST		LABOR COST	
	DEBUG	ACCEPT	DEBUG	ACCEPT	DEBUG	ACCEPT
S1 S&A MODULE LOWER SUBASSEMBLY						$ 25
11720304 Pin Module	17,800	9,000	$ 56	$ 28		
11720322 Shaft Spin Lock	8,800	4,500	40	20		
11720318 Spacer, Gear Plate	4,400	2,250	83	43	1,053	729
S2 S&A MODULE LOWER SUBASSEMBLY						26
11720335 Plate, Bottom	4,400	2,250	86	45	269	1,416
11720324 Pin Rotor Lock	4,400	2,250	33	17	314	166
11720323 Disk Lock Pin	4,400		20			
S3 LOWER PLATE & SHAFT ASSEMBLY						14
11720321 Plate L. Gear	4,400	2,250	779	397	9,393	8,513
11720320 Shaft, Pallet	4,400	2,250	84	48	335	304
S4 SPRING LOCK PIN						
11720325 Lock Pin Spring	4,400	2,250	17	9	495	464
S5 S&A SUBASSEMBLY						28
11711728 Gear & Pinion	4,400	2,250	395	202	3,659	1,964
11720308 Wheel & Pinion	4,400	2,250	380	195	3,659	1,965
11720303 U. Gear Plate	4,400	2,250	174	92	4,998	2,863
11720328 Spin Lock	8,800	4,500	93	47	1,146	655
11720309 Pallet	4,400	2,250	14	8	3,137	1,685
11720319 LP & Shaft	Parts from S3				302	
11720305 R. Assembly	Parts from S6				203	
11720327 Spring SP/LK	Parts from S7					

TABLE E-IX. DEBUG AND ACCEPTANCE HARDWARE COSTS (ADDITIONAL COSTS REQUIRED DUE TO DUPLICATION OF MACHINES S9, S10, E1, AND E2) (CONTINUED)

MACHINE LINE	PARTS QTY		MAT'L COST		LABOR COST	
	DEBUG	ACCEPT	DEBUG	ACCEPT	DEBUG	ACCEPT
S6 <u>ROTOR ASSEMBLY</u>						$ 28
11720306 Rotor Body	4,400	2,250	$ 82	$ 42	$ 2,322	1,222
11720330 Rotor Gear	4,400	2,250	58	30	1,536	808
11720329 Rotor Shaft	4,400	2,250	78	40	314	166
S7 <u>SPRING SPIN LOCK</u>						
11720327 Spin Lock Spring	8,800	4,500	18	9	980	459
S8 <u>S&A SUBASSEMBLY</u>						34
11720310 Lead (Live)		2,250		576		
11720310A Lead (Inert)	4,400		240			
11720302 Can	4,400	2,250	297	152	461	306
S9 <u>ARM CHECK</u>	Parts from S8					1,796
S10 <u>S&A MODULE</u>						1,585
11720317 Disk Setback	4,400	2,250	17	9		
11720335 Setback Pin	4,400	2,250	68	35		
S11 <u>SPRING SETBACK</u>						
11720334 Spring	4,400	2,250	7	4	607	253

TABLE E-IX. DEBUG AND ACCEPTANCE HARDWARE COSTS (ADDITIONAL COSTS REQUIRED DUE TO DUPLICATION OF MACHINES S9, S10, E1, AND E2) (CONCLUDED)

MACHINE LINE	PARTS QTY		MAT'L COST		LABOR COST	
	DEBUG	ACCEPT	DEBUG	ACCEPT	DEBUG	ACCEPT
E1 CUP & COVER ASSEMBLY						$ 563
11711410 Cup	4,400	2,000	$ 12,427	$ 5,649		
11711417-2 Contact Pad	8,800	4,000	163	37		
11711418 Contact Coil	13,200	6,000	415	189		
11711409 Cover	4,400	2,000	201	91		
E2 NOSE PLUG ASSEMBLY						563
11711407 Nose Plug	4,400	2,000	812	369		
11711417-2 Pad Contact	4,400	2,000	82	37		
11711450-1 Setting Ring	4,400	2,000	3,267	2,510		
11711450-2 Setting Ring	4,400	2,000	3,267	2,510		
Total Additional Hardware for Duplicate Machines (with Acq.)			23,753	13,440	$ 34,642	$29,142
Total Hardware Page 7			138,743	160,952	93,484	57,795
Subtotal			$162,496	$174,392	$128,126	$86,937

	DEBUG		ACCEPT		TOTAL
TOTALS	$290,622	+	$261,329	=	$551,951

NOTE: Labor costs include piece part manufacturing costs and labor to debug and run acceptance tests of the machines and equipment.

TABLE E-X. VENDOR TOOLING COSTS

PART NUMBER	TOOL DESCRIPTION	QTY.	MAT'L $
1. 11711407	MOLD FOR NOSE PLUG	1	$ 16,640
2. 17111409	MOLD FOR ELECTRIC COVER	1	19,648
3. 17111411	PWB #1 TOOLING	1	11,860
4. 17111412	PWB #2 TOOLING	1	9,735
5. 11711419	DIE (FRAME, LEAD STRIP)	1	4,855
6. 11718234	DIE (CLIP, DETONATOR)	1	3,300
7. 11720247	DIE (TEST VEHICLE BODY)	1	1,125
8. 11720258	OUTPUT LEAD TOOL	1	65,000
9. 11720295	MOLD (DUMMY BOOSTER PELLET)	1	325
10. 11720297	DIE (CONTACT, DETONATOR)	1	5,600
11. 11720299	MOLD (INSULATOR, DET. CONT.)	1	11,012
12. 11720307	DIE (GEAR & PINION NO. 1 ASSY.)	1	4,895
13. 11720308	DIE (ESCAPEWHEEL & PINION ASSY.)	1	4,895
14. 11720328	MOLD (SPINLOCK)	1	2,500
15. 11722405	EXPLOSIVE TOOLING (ELECT. DET.)	1	47,500
16. 28107993	DIE (SHORTING CLIP)	1	375
17. 11711408	NOSE CONE (TOOLS & GAGES)	Set	6,100
18. 117 1416-1	RING (P.P. DIE)	1	3,000
19. 11711416-2	RING (P.P. DIE)	1	3,000
20. 11722622	SLEEVE (TOOLS & GAGES)	Set	15,200
21. 11720296-1	BIAS SPRING (P.P. DIE)	1	10,100
			$246,665
	Material Acquisition Rate		4.8%
	TOTAL		$258,505

TABLE E-XI. MANUFACTURING TOOLING COSTS

PART NUMBER	NAME	TOOL DESIGN	TOOL MAKE	MAT'L $	TOTAL COST
1. 11711410	ORIENTATION CUP			161,000	
2. 11720214	CLIP	24	150	900	
3. 11720335	BOTTOM PLATE	10	375	50	
4. 11720323	LOCK PIN DISK	40	250	350	
5. 11720321	LOWER GEAR PLATE	10	800	1,000	
6. 11720318	SPACER	10	375	50	
7. 11720306	ROTOR BODY	10	250	200	
8. 11720330	ROTOR GEAR	10	750	200	
9. 11720309	PALLET	10	375	200	
10. 11720303	UPPER GEAR PLATE	10	850	1,000	
11. 11720302	CAN, S&A MODULE	125	500	750	
12. 11720317	DISK, SETBACK	75	400	500	
		334	5,075	166,200	
Labor Rates/Mat'l Acq.		$15.33	$17.41	4.8%	
TOTALS		$5,120	$89,878	$174,178	$269,176

TABLE E-XII. ASSEMBLY TOOLING COSTS (NONRECURRING PRODUCTION OF 225,000 UNITS)

PART NUMBER	PART NAME	TOOL DESCRIPTION	FLOW DIAG IDENT	QTY	TOOL DESIGN HRS.	TOOL MAKE HRS.	MAT'L $ WITH ACQ.
1. 11720301	S&A MODULE	Gear Train Assy. Fixt.	S 5	5	40	625	$ 5,764
2. 11720301	S&A MODULE	5000 RPM Spin	S 8	1	20	160	5,240
3. 11720301	S&A MODULE	45° Spin Crimp	S 8	1	60	280	2,096
4. 11720301	S&A MODULE	90° Spin Crimp	S 8	1	---	280	2,096
5. 11720301	S&A MODULE	Lead Cup Staker	S 8	1	24	100	2,305
6. 11720300	S&A MODULE	Arm Check	S 9	2	100	800	24,900
7. 11720300	S&A MODULE	Non-Arm Check	S 9	2	50	400	10,470
8. 11720300	S&A MODULE	Setback Pin Assy.	S10	1	40	200	3,668
9. 11720300	S&A MODULE	Safety Spin Check	S10	1	20	160	5,240
10. 11720313	S&A SUBASSEMBLY	Magazine	S 2	430	---	----	3,110
11. 11720325	LOCK PIN SPRING	Magazine	S 4	250	---	----	2,874
12. 11720305	ROTOR ASSEMBLY	Magazine-Rotor	S 6	313	---	----	2,260
13. 11720305	ROTOR ASSEMBLY	Tray-Det.	S 6	75	---	----	629
14. 11720305	ROTOR ASSEMBLY	Magazine-Det.	S 6	1500	---	----	7,860
15. 11720334	SETBACK SPRING	Magazine	S11	335	---	----	2,510
16. 11720327	SPINLOCK SPRING	Magazine	S 7	500	---	----	3,747
17. 11722620	DET. BLK. ASSY.	Stake G. Pin Clip	F 1	1	40	200	1,572
18. 11722620	DET. BLK. ASSY.	ASM Roll Pin to Sleeve	F 3	2	40	400	3,144
19. 11720291	R. FITTING ASSY.	Stake Lead Cup/Sleeve	F 3	1	30	150	2,096
20. 11720291	R. FITTING ASSY.	ASM. S&A	F 4	4	24	120	210
21. 11720291	R. FITTING ASSY.	ASM. Bias Spring	F 4	4	24	120	210
22. 11720291	R. FITTING ASSY.	Stake Components	F 4	2	40	200	2,096
23. 11711413	PWB #1 ASSY.	Tool Plate	AS3	1	32	36	210
24. 11711413	PWB #1 ASSY.	Tool Plate	AS5	1	16	36	210
25. 11711414	PWB #2 ASSY.	Tool Plate	AS6	1	16	36	210
26. 11718418	IMPACT SWITCH	Lead Former	Bench 1	1	---	----	839
27. 11711413	PWB #1 ASSY.	Holding Fixture	Bench 1	20	---	----	10,060
28. 11711414	PWB #2 ASSY.	Holding Fixture	Bench 2	20	---	----	3,773
29. 11711413-414	PWB ASSEMBLIES	W. Solder Clips	W.S.	300	---	----	1,572
30. 11711414	PWB #2 ASSY.	Mask Mold-Ladder	W.S.	1	30	150	420

TABLE E-XII. ASSEMBLY TOOLING COSTS (NONRECURRING PRODUCTION OF 225,000 UNITS) (CONCLUDED)

PART NUMBER	PART NAME	TOOL DESCRIPTION	FLOW DIA IDENT	QTY	TOOL DESIGN HRS.	TOOL MAKE HRS.	MAT'L $ WITH ACQ.
31. 11711414	PWB #2 ASSY.	Mask Mold-N. Plug	W.S.	1	30	100	$ 420
32. 11711414	PWB #2 ASSY.	Mask Mold-O. Cup	W.S.	1	30	120	420
33. 11711413	PWB #1 ASSY.	Punchout Die	P.O.#1	1	40	160	1,048
34. 11711414	PWB #2 ASSY.	Punchout Die	P.O.#2	1	40	160	1,048
35. 11711425	NOSE PLUG ASSY.	Heat Stake Fixture	E 2	3	16	180	330
36. 11711425	NOSE PLUG ASSY.	Height Tool	E 2	3	8	60	94
37. 11711428	CUP & COVER ASSY.	Assy. Fixture	E 1	3	8	90	94
38. 11711428	CUP & COVER ASSY.	Staking Fixture	E 1	3	24	240	755
39. 11711428	CUP & COVER ASSY.	Height Tool	E 1	3	8	60	63
40. 11711428-1	ELECTRONICS ASSY.	Marking Tool	Bench 3	2	---	----	4,820
41. 11711428-1	ELECTRONICS ASSY.	Soldering Fixture	Bench 3	30	---	----	1,533
42. 11711428-1	ELECTRONICS ASSY.	Troubleshoot Test	Bench	3	---	1070	51,510
43. 11711430	E-HEAD ASSY.	Pressing Ring	E 3	2	4	50	105
44. 11711430	E-HEAD ASSY.	Pressing Head	E 3	2	4	25	105
45. 11711430	E-HEAD ASSY.	Holding Fixture	E 3	5	6	75	105
46. 11711430	E-HEAD ASSY.	Staking Fixture	E 3	5	20	50	31,126
47. 11711430	E-HEAD ASSY.	Potting Fixture Mold	P 1	1	---	----	4,716
48. 11711430	E-HEAD ASSY.	Potting Conveyor	P 1	1	---	----	2,515
49. 11711430	E-HEAD ASSY.	Trimming Fixture	E 4	1	549	2380	31,860
50. 11711430	E-HEAD ASSY.	Index Tool Mold	T1-T2	1	---	----	4,716
51. 11711433	FUZE ASSY.	Index Tool Mold	T3	1	---	----	4,716
52. 11711433	FUZE ASSY.	Crimp Index Table	F 5	1	100	400	1,865
53. 11711433	FUZE ASSY.	Marking Tool	Bench 4	2	---	----	5,785
54. 11711433	FUZE ASSY.	Index Table	T3	2	---	----	9,432
55. 11711433	FUZE ASSY.	Data Key Punch	T3	1	---	----	3,862
	Subtotals				1533	9,673	
	Labor Rates				$15.33	$17.71	
	TOTALS				$23,501	$171,309	$277,862 =

$\boxed{\$472,672}$

TABLE E-XIII. ASSEMBLY TOOLING COSTS (IPF)

TOOL DESCRIPTION	FLOW DIAG. IDENT.	QTY.	MAT'L $	TOTAL $
1. 12 STATION INDEX TOOL FOR POTTING DISPENSER MOLDS	PI	1	$ 4,500	
2. 12 STATION INDEX TABLE FOR SET/INTER TEST STATION	T3	2	9,000	
3. HOLDING FIXTURES	Bench #1	80	9,600	
4. HOLDING FIXTURES	Bench #2	30	3,600	
5. HOLDING FIXTURES	Bench #3	65	1,950	
6. AUTOMATIC INSERTION EQUIP. PCB HOLDING FIXTURES	AS3	1	820	
7. TROUBLESHOOT TEST STATIONS	-	2	40,000	
8. FIXTURING FOR WAVE SOLDER MACHINE	W.S.	1Set	3,000	
9. MAGAZINES - S&A MOD. L. SUBASSEMBLY	S2	430	2,967	
10. MAGAZINES - LOCKPIN S.W.	S4	250	1,788	
11. MAGAZINES - S&A SUBASSEMBLY	S5	860	5,934	
12. MAGAZINES - ROTOR ASSEMBLY - DET. TRAY	S6	75	600	
13. MAGAZINES - ROTOR ASSEMBLY - EJECT	S6	313	2,156	
14. MAGAZINES - ROTOR ASSEMBLY - DET. MAG.	S6	1500	7,500	
15. MAGAZINES - SPIN LOCK SPRING	S7	500	3,575	

TABLE E-XIII. ASSEMBLY TOOLING COSTS (IPF) (CONCLUDED)

TOOL DESCRIPTION	FLOW DIAG. IDENT.	QTY.	MAT'L $	TOTAL $
16. MAGAZINES - S&A SUBASSEMBLY	S8	715	$ 4,934	
17. MAGAZINES - S&A ARM CHECK	S9	800	5,520	
18. MAGAZINES - FINAL	S10	1000	6,900	
19. MAGAZINES - SETBACK PIN S.W.	S11	335	2,395	
20. MAGAZINES - DET BLOCK	F2	1000	9,000	
21. MAGAZINES - POWER SUPPLY	F2	1000	10,000	
22. MAGAZINES - R.F. OUTPUT LEAD	F3	3000	15,000	
23. MAGAZINES - ORIENTATION CUP	E1	854	7,686	
Subtotal			158,425	
Acquisition Rate			4.8%	
TOTAL				$166,030

TABLE E-XIV. MATERIAL HANDLING COSTS

PART NUMBER	NAME	MH DESCRIPTION	QTY.	MAT'L $	TOTAL COST
1. 11711413	PWB ASSEMBLY	Square Tray (Static Free)	2000	$ 6,000	
11711414	PWB ASSEMBLY	Square Tray (Static Free)	2000	6,000	
2. 11711428-1	ELECTRONICS ASSEMBLY	Circular Tray (Static Free)	3000	10,500	
3. 11711430-1	ELECT. & NOSE CONE ASSY	Circular Tray (Static Free)	3000	10,500	
4. 11711430-1	UNPOTTED E-HEAD	Potting Holder Trays	8000	28,000	
5. 11711433	FUZE (LESS BOOSTER PELLET)	Crates	8000	20,000	
6. 11720300	S&A MODULE	Shelf Truck (Spring Mag)	6	900	
7. 11720300	S&A MODULE	Shelf Truck (Module Mag)	14	2,100	
8. --------	----------	Miscellaneous	----	10,000	
Subtotal				94,000	
Acquisition Rate				4.8%	
TOTAL				$98,512	

TABLE E-XV. GAGE AND INSPECTION EQUIPMENT COSTS
(NONRECURRING PRODUCTION OF 225,000 UNITS)

GAGE FOR PART NO.	NAME	QTY.	TOOL DESIGN	TOOL MAKE	MAT'L $	TOTAL COST
HONEYWELL PIECE PART GAGES						
1. 11711408	NOSE CONE	1	50	4	$ 8,460	
2. 11720206	CUP	1	16	0	2,650	
3. 11722623	SLEEVE	1	79	4	23,930	
4. 11720327	SPRING	1	24	52	1,550	
5. 11720298	BLOCK	1	11	------	1,750	
6. 11718234	CLIP	1	2	3	15	
7. 11720335	BUTTOM PLATE	1	21	25	2,500	
8. 11720321	LOWER GEAR PLATE	1	-----	25	2,000	
9. 11720318	SPACER	1	35	------	5,000	
10. 11720306	ROTOR BODY	1	32	100	3,700	
11. 11720306	ROTOR BODY	1	43	250	650	
12. 11720309	PALLET	1	18	132	270	
13. 11720303	U. GEAR PLATE	1	20	4	1,750	
14. 11720302	CAN	1	3	8	235	
15. 11720312	DISK	1	2	0	125	
Hours			356	607	$ 54,585	
LB Rates/Mat'l Acq.			$15.33	$17.71	4.8%	
SUBTOTALS (This Sheet)			$5,457	$10,750	$ 57,205	$73,412

TABLE E-XV. GAGE AND INSPECTION EQUIPMENT COSTS
(NONRECURRING PRODUCTION OF 225,000 UNITS) (CONCLUDED)

PART NUMBER	GAGE NO. OR DESCRIPTION	QTY	TOTAL $	FUNCTION/DESCRIPTION
E-HEAD & FUZE GAGES				
1. 11711408	H11711408G1	2	$ 400	Stage
2. 11711428	H11711428G1	2	650	2.207 max.
3. 11711428	(3.140 Max.)	3	1,775	3.140 max
4. 11711428	H11711428G2	2	1,200	⊕ | A | B | .015 DIA 3 places
5. 11711435	H11711433E1	1	290	Crimp Joint Tester
6. 11720296	GGIT	2	1,000	Load Gage
7. 11720307	OG20350	2	700	Roll Gage
8. 11720307	OG38123M1	1	600	Master Gear
9. 11720308	OG38125M1	1	600	Master Gear
10. 11722622	GGIU	5	2,500	Runout Gage
11. 11722622	H28107890G1	2	550	1.700 + .005
12. 11722622	GGID GO	5	515	2.000 - 12 UNS - 1A/GO
13. 11722622	GGIE NO-GO	5	515	2.000 - 12 UNS - 1A/NO GO
14. 11722622	GGIH	5	600	1.600 - 20 UNS - 2A LH
15. 11722622	GGIK	5	600	1.600 - 20 UNS - 2A LH
16. 11720206	GGIN D.E.P.	5	400	1.600 - 20 UNS - 2B LH
17.	Impact Sw. Test Fix.	1	1,700	
18. 11720300	S&A Spin Test Fix.	1	18,000	Temperature Controlled
19. 11720300	S&A Centrifuge Fix.	1	500	
20.	IC Tester Handler	2	75,000	1 for each Hybrid Circuit
21.	Cap. Bridge	1	35,000	Required for tear drop
22.	Leak Test Fixture	1	2,300	capacitors only.
23.	TV Adaptor(HOPG Testing)	1	1,700	
24.	LAT Test Material	1Set	6,875	
25.	5' Drop Test Fix.	1	500	
26. 11720206	Set Plug Gage	1	105	1.600 - 20 UNS - 2A
			$154,575	
	Mat'l Acquisition Rate		4.8%	
	Subtotal (This Sheet)		$161,995	
	Subtotal (Page 1)		73,412	
	TOTAL			$235,407

TABLE E-XVI. GAGE AND INSPECTION EQUIPMENT COSTS (IPF)

GAGE FOR PART NO.	NAME/ FUNCTION	QTY.	TOOL DESIGN	TOOL MAKE	MAT'L $	TOTAL COST
HONEYWELL MACHINE MASTERS						
1. 11720313	S&A MODULE Flush to Below	2	4	24	$ 4	
2. 11720319	L. PLATE & SHAFT .177 Max Height	2	4	30	4	
3. 11720301	S&A SUBASSEMBLY .532 Max.	2	4	24	4	
4. 11720305	ROTOR ASSEMBLY 1 lb. Push	2	5	22	10	
5. 11720305	ROTOR ASSEMBLY Gear Flush to .053 Below	2	5	20	8	
6. 11720305	ROTOR ASSEMBLY .237 Max Height	2	3	18	4	
7. 11720300	S&A SUBASSEMBLY .564 Max Height	2	4	20	4	
8. 11711428	CUP & COVER .020 Max Stake Height	2	5	18	6	
9. 11711425	NOSE PLUG ASSY. .613 Max Height	2	4	20	4	
10. 11711425	NOSE PLUG ASSY. Flatness	2	8	34	10	
11. 11720291	REAR FITTING 1.644 Dimension	2	6	30	10	
12. 11720291	REAR FITTING .215 Max Height	2	6	20	10	
13. 11711428	CUP & COVER 3.140 Max Dim.	2	---	60	40	
14. 11720291	REAR FITTING	1	---	90	600	
	Hours		58	430	$718	
	LB Rates/Mat'l Acq.		$15.33	$17.71	4.8%	
	SUBTOTALS (This Sheet)		$889	$7,615	$753	$9,257

TABLE E-XVII. GOVERNMENT-FURNISHED MATERIAL (GFM) REQUIREMENTS (NONRECURRING PRODUCTION OF 225,000 UNITS - TOOLING TRYOUT)

PART NUMBER & NAME	QTY. OTHER	QTY. DEBUG HARDWARE	QTY. ACCEPT HARDWARE
1. 11720216 BATTERY POWER SUPPLY		1000 (Dummy)	1000 (Live)
3. 8798331 M55 DETONATOR		1000 (Inert)	2000 (Live)
4. 8864492 AMMO BOXES WITH TOP & BOTTOM SUPPORTS			100
5. 8886458 WIRE BOUND BOX			50

TABLE E-XVIII. GOVERNMENT-FURNISHED MATERIAL (GFM) REQUIREMENTS (IPF)

PART NUMBER & NAME		QUANTITY (OTHER)	QUANTITY DEBUG HARDWARE	QUANTITY ACCEPT HARDWARE
1. 11720216	BATTERY (POWER SUPPLY	-	8,800 (Dummy)	5,100 (Live)
2.	XM36 SETTER	23	-	-
3. 8798331	M55 DETONATOR	-	17,600 (Inert)	10,500 (Live)
4. 8864492	AMMO-BOX WITH TOP & BOTTOM SUPPORTS	-	-	100
5. 8886458	WIRE BOUND BOX	-	-	50

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